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A MAGAZINE OF METHODS FOR OPERATING MEN

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Accompanying this issue as Section Two is a subject and author's index of articles published in Vol. 9 of The Petroleum Engineer. The 1937 index appeared in the issue of February, 1938.

MEETINGS

California Natural Gasoline Association—December 1, Richfield Building, Los Angeles, California.

•

American Society of Mechanical Engineers—December 5, 6, 7, 8, and 9, New York City.

•

Oil and Gas Association of Michigan, Annual Meeting — December 7, Mt. Pleasant, Michigan.

•

West-Central Texas Oil and Gas Association, Annual Meeting —December 10, Abilene, Texas.

•

Society of Automotive Engineers, Annual Meeting — January 9, 10, 11, 12, and 13, Detroit, Michigan.

•

Indiana Independent Petroleum Association, Spring Convention and Refiners' and Suppliers' Exhibit—March 14, 15, and 16, Hotel Severin, Indianapolis, Indiana.

•

American Association of Petroleum Geologists—March 22, 23, and 24, Oklahoma City, Oklahoma.

•

American Chemical Society—April 3, 4, 5, 6, and 7, Baltimore, Maryland.

•

Oil-World Exposition — April 24, 25, 26, 27, 28, and 29, Houston, Texas.

•

Petroleum Industry Electrical Association—May 2, 3, and 4, Rice Hotel, Houston, Texas.

•

Petroleum Electric Supply Association—May 2, 3, and 4, Houston, Texas.

•

International Petroleum Exposition—May 18, 19, 20, 21, 22, 23, 24, and 25, 1940, Tulsa, Oklahoma.

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The Course of Oil

By K. C. SCLATER

Further Cooperation Needed

To widen and improve the usefulness of petroleum conservation by state authority and by interstate coöperation, the president of the American Petroleum Institute in his annual address at Chicago this month presented a sane plea when he said:

"Some states and some pools and some operators have contributed more to the industry's progress than have others. This raises the pertinent question as to what may properly be done to improve the long-term outlook in this business and brings us to a consideration of the basic subject of conservation and the role which proration plays in offsetting the industry's old man of the sea—the rule of capture. Conservation means the production of the maximum amount of crude oil from a pool at the least possible cost. Conservation means the prevention of waste, whether above or below ground—it does not mean fixed prices or the fixing of prices. Nor can conservation be justified as a price factor, but price itself is an unavoidable factor in proration. Were it not for the vast reserves contained in the pools of settled production, as typified by the stripper well areas, conservation might begin and end in the simple process of allowing flush pools to produce at a rate which would permit recovery of the maximum yield at the lowest cost. If this procedure resulted in overproducing the market demand, as unrestrained production in the past has often done and undoubtedly could do in the future, price punishment inevitably would slow it down. But the problem of conservation is not so simple as that, and thus the market demand clauses in the conservation laws of a number of states assume a vital importance in preventing floods of unrequired production and resultant decline in prices which would prove ruinous to thousands of operators. From the standpoint of conservation itself, such prices, if long continued, would either destroy the reserves in fields which could not be produced under such conditions, or would make the cost of ultimate recovery from such fields so excessive as to be seriously burdensome to the ultimate consumer.

It is recognized that proration cannot serve as a vehicle of conservation or, in fact, indefinitely endure, unless it is administered equitably, not only between wells in a pool, but between pools within states and also pools competing in the same trade channels regardless of state lines. It is also becoming generally recognized that proration reaches economic limits in cases where over-drilling reduces well allowables to the point where adequate return is not available for the capital and risk involved. Prevention of this requires proper drilling patterns or well spacing. It is generally conceded that only by the intervention of the conservation authorities of the states, implemented with essential legislation under the states' police power, can this be brought about.

It is my personal belief that conservation, through proration based upon proper well spacing and production practices, will not and should not bring fixed or pegged price crude oil. That from time to time the power of a flexible price will and should take charge of the situation, encouraging or discouraging development and production, thus tending to keep them within economic requirements. This industry has no right to special price consideration other than that essential to prevent physical waste. It seems to me, however, that under proper conservation practices, much narrower swings in the price trend are likely to occur than were experienced prior to production under proration. In other words, let me say, merely by way of illustration, that something like a five or ten cent increase or decrease in the price of a barrel of crude oil rather than violent fluctuations upward or downward should be a logical and wholesome development of the proration system. Conservation through proration must presuppose a fair and reasonable price to the producer of petroleum, not only to encourage him to find and develop pools but to conserve and make available the vast reserves within pools of settled production.

This brings us to a consideration of how conservation by state authority and interstate coöperation, which has made such commendable progress during the last few years, may widen and improve its field of usefulness. First, I believe that government and industry are agreed that the Connally Act, preventing interstate shipment of oil illegally produced, should be renewed and made permanent. Second, that state and federal approval of the continuance of the Interstate Oil Compact should be given. Third, that all states which are producing petroleum should join the compact and those lacking conservation laws should enact them, and in such form as to gain the benefit of modern engineering and scientific knowledge, which makes possible proper well patterns and proper conservation of reservoir energy.

In the long run a state, like an individual, does not profit by trying to live unto itself alone but best profits and best serves by coöperation with other states in matters of wide public concern. The compact authority has not and, in my opinion, never should have powers of compulsion. Its power and usefulness rest upon the fact that it provides a forum for exchange of information, discussion, and recommendation, leaving to its member states complete independence of decision on the action to be taken.

The record of the Interstate Oil Compact Commission during the three years of its existence has been a commendable one. No member of the Commission would, I am sure, disagree with the statement that there remains much more to be accomplished for state and national welfare than the Commission within the short period of its existence has as yet been able to accomplish. The Commission will be seriously handicapped, however, unless it has the full and complete coöperation of all producing states, particularly Illinois, Louisiana, Arkansas, Michigan, and California. The State of Illinois is already a member of the Compact but has not as yet adopted a conservation law. If, as we are convinced, oil pools developed and produced in accordance with now known sound engineering practices, will yield a volume of petroleum greatly in excess of the amount which would be recovered under the old anti-conservation methods, enlightened selfishness would indicate the adoption of sound conservation laws by states which at present have no such laws, and improvements, by amendment, to those laws in states which are not abreast of current engineering knowledge."

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« « HIGHLIGHTS IN OILDOM » »

Two-Day Shutdown Likely to Continue

The Texas Railroad Commission indicates the existing two-day shutdown likely will be continued through December. Definite announcement will be made after the hearing November 18 at which time testimony will be heard upon which the December proration order will be based. Purchasers of East Texas oil have notified the commission they will coöperate in the effort to provide an outlet for approximately 500 wells that are without connections if the five-day producing week is continued.

Ernest O. Thompson, chairman of the Railroad Commission, says it appears the five-day week throughout the state during December will be sufficient to supply the needs of purchasers. He further states there are 565 unconnected wells in the state, 500 of them in East Texas.

●

May Seek Embargo on All Mexican Crude Oil

The United States Congress may be asked to declare an absolute embargo upon importations of all crude oil from Mexico, whether expropriated from American or other nationals, or legitimately produced under conditions that permit shipment to the United States by payment of the excise tax, and then undersell the market here. Copies of a joint resolution are being circulated, which would give the President authority to apply an embargo in the case of confiscated oil or its by-products. The resolution relates only to oil imported from a foreign government that has refused or within one year after confiscation has failed to make restitution or payment for the seized properties.

●

"Hot Oil" Confiscation Act Held Constitutional

Texas' "hot oil" confiscation act was held constitutional by a recent ruling of the State Supreme Court, which refused to grant a writ of error in the Third Court of Civil Appeals' decision upholding the act. Although this was the first affirmance of the act by the Supreme Court of Texas, its validity previously had been upheld by the Supreme Court of the United States.

The action of the Supreme Court of Texas was one of three rulings concerning oil regulations in East Texas and in each case the State and the Railroad Commission won the decision. The court refused to review the case of Skipper-Bivens Oil Company et al. vs. the State, finding no error in the appellate court's decision of last March. In another confiscation suit, J. I. Dyer vs. the Railroad Commission and the State, the court held it was without jurisdiction to grant a writ of error, which left in force a decision of the Court of Civil Appeals denying Dyer an injunction to force issuance of a tender and ordering the oil in question confiscated, as sought by the state. In the third suit, the Supreme Court denied a rehearing sought by the Beaver Reclamation Oil Company from a prior ruling affirming the right of the Railroad Commission to require permits for the trapping or picking up of abandoned oil and denying a tender on oil involved.

Allegation of the unconstitutionality of the confiscation act was urged in both the Skipper-Bivens and Dyer cases. The controlling opinion of the Court of Civil Appeals, which is left in force, was delivered in the former.

●

Believe Crude Oil Price is Too Low

Whether producers can compel purchasers to pay for crude oil on the basis of the average cost of crude production, including the costs of stripper wells, was a major issue confronting the National Stripper Well Association and the Independent Petroleum Association of America at their annual meetings recently.

Charles F. Roeser of Fort Worth, Texas, president of the I.P.A.A., declared that "the present price cuts and the general disturbing situation throughout the petroleum industry cause me to believe that the time is ripe for establishing a price structure which takes into consideration costs and values."

He contended that a fair price for 36-gravity Mid-Continent crude petroleum should be $1.60 per bbl. or more.

"The wide gap between such a figure and the current price suggests the loss which producers now are suffering," Roeser declared.

Discussion of price structure correction naturally involved several other vital "planks" of the Independent Petroleum Association's platform, each of them having some relationship to the problem of price. For instance, limitation of imports and an increase in the excise taxes would tend to support domestic crude prices, while authorization by Congress of voluntary trade agreements within the industry subject to approval by some designated federal authority may constitute another factor in stopping sales below cost, Roeser pointed out.

●

Netherland Indies Oil Reserves Disappointing

The United States Department of Interior comments in a recent issue of its publication *International Petroleum Trade* upon an article appearing in *Java Bode* concerning the petroleum situation in Netherland Indies. The article described the policy of the government to protect the large capital investment in refineries and the regularity of its revenue from them by doling out new fields in a manner to keep them working as long and as steadily as possible, and reviewed the generally unsuccessful efforts of oil companies in the country to find new reserves in the vast exploration and exploitation areas conceded to them in the last seven years. The conclusion of the writer was that the Indies are not rich in petroleum, and that the last hope, except for some piece of unforeseen luck, lies in the possibility that exploitable fields may be found in New Guinea. According to him, the refinery at Soengei Gerong, Palembang, will have to reduce its daily output from 40,000 to 30,000 or 35,000 bbl. within the next year or two if new reserves are not discovered.

The Month's Activities in Refining

Percent Refining Capacity Operated

Western Division, 60.1 Percent **Central Division, 78.3 Percent** **Eastern Division, 81.2 Percent**

CONTINENTAL OIL COMPANY has announced plans for a building program involving the expenditure of $1,500,000 to enlarge the capacity of its Ponca City, Oklahoma, refinery. A contract involving $1,250,000 of the total has been let to M. W. Kellogg Company and work will begin January 1. The principal installation will be a Cross cracking unit, and the rest of the expenditure will be used in remodeling the plant and reconditioning the equipment.

This program follows recent expansion work at the Continental Oil Company's Denver, Colorado, refinery costing $500,000, and work at the eight other refineries of the company.

●

Anglo-Canadian Oil Company may construct a 5000-bbl. refinery at Calgary, Alberta, Canada, according to F. P. Byrne, managing director of the company. Work would not begin until in the spring.

●

At its Baytown, Texas, refinery the Humble Oil and Refining Company is constructing a phenol plant to cost $1,000,000. It is expected to be completed in about five months.

●

According to a recent announcement, Cowan Oil and Refining Company is planning to rebuild and recondition its Rosecrans natural gasoline plant in the Rosecrans field, Los Angeles Basin, California. The plant has not been in operation for several years. Some of the existing equipment will be reconditioned and used although considerable new equipment also will be required.

●

The Tide Water-Associated Oil Company and the Seaboard Oil Company have granted a contract to J. F. Pritchard and Company for an addition to their new gas recycling plant in the Cayuga field, Texas. The plant, designed by William H. "Jack" Vaughn, under patents owned by the company, has been in operation since March 1 extracting gasoline from the gas and returning the residue to the producing formation.

The Talco Asphalt and Refining Company, Mt. Pleasant, Texas, has converted one of its cracking coils into a reducing still to reduce asphalt production from 45 percent to 15 percent yield and also to provide clean cracking stock for the cracking units.

●

Roeser and Pendleton, Inc., have made application to the Texas Railroad Commission for a permit to construct a recycling plant in the Cayuga field, Anderson County. After extraction of gasoline from the gas the residue would be utilized to repressure the Woodbine sand.

●

Sunray Oil Company has contracted with Universal Oil Products Company for a catalytic polymerization unit at its Allen, Oklahoma, refinery, it has been announced by F. L. Martin, vice-president of Sunray. The unit is expected to be in operation by December 1, 1939.

●

The Sun Oil Company and the Socony-Vacuum Oil Company have entered into a contract with the Houdry Process Corporation for the construction of several units used in the Houdry process of refining. Sun will spend $11,000,000 and Socony-Vacuum $25,000,000. E. B. Badger and Sons, Boston, Massachusetts, is the licensing agent. Sun will construct two units and Socony-Vacuum eight. The Socony-Vacuum units are at Beaumont, Texas, (two); Brooklyn, New York; Buffalo, New York; Augusta, Kansas; Detroit, Michigan; East St. Louis, Illinois; and Paulsboro, New Jersey.

●

The Western Supply Company, Tulsa, Oklahoma, has been awarded a contract to construct an absorption and repressuring plant in the Agua Dulce field, Nueces County, Texas. The plant will have a capacity of 75,000,000 cu. ft. of gas per day. The gas will be supplied by L. M. Lockhart and G. P. Shelton. Completion of the plant, which is to be situated on the Ollie Purl farm 30 miles west of Corpus Christi, is scheduled for December 15th.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ending October 29, 1938

A.P.I. Figures
(Figures in Barrels of 42 Gal. Each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	476,000	77.4	17,082	16,751
Appalachian	85.9	96,000	75.0	2,802	916
Ind., Ill., Ky.	89.5	469,000	91.2	10,191	9,394
Okla., Kans., Mo.	81.6	237,000	69.3	6,164	4,718
Inland Texas	50.3	98,000	61.6	1,523	2,050
Texas Gulf	88.9	763,000	91.1	9,930	14,797
La. Gulf	97.3	127,000	87.6	2,202	3,123
No. La. & Ark.	55.0	45,000	81.8	408	834
Rocky Mt.	54.2	37,000	57.8	1,053	781
California	90.0	465,000	62.4	12,695	96,975
Reported	85.6	2,813,000	78.0	64,050	150,339
Estimated Unreported	.....	332,000	.....	3,540	3,380
*EST'D TOTAL U. S. OCT. 29, '38	.....	3,145,000	.....	67,590	153,719
*EST'D TOTAL U. S. OCT. 22, '38	.....	3,230,000	.....	67,695	152,796
U. S. B. of M. *OCT. 29, '37	.....	**3,388,000	.....	67,865	120,008

*Estimated Bureau of Mines' basis.
**October, 1937, daily average.

Latest Activities In The Oil Fields

T. J. TUCKER et al.'s No. 1 Sam Bane, in the Webb Survey eight miles east of Buffalo, Leon County, Texas, the first oil well in the county, produced erratically when completed at a depth of 5510 to 5520 ft. through casing perforations. The well was originally drilled deeper but produced water through casing perforations at a depth of 5534 to 5544 ft. and was plugged to 5524 feet. The oil is black in color and the gravity is about 25 to 27 deg. A.P.I., which is unusually low for oil produced from the Woodbine sand. The water content is high; however, the source of the water is not known. The reservoir pressure seems to be declining rather rapidly. Although the production from the well may prove to be insignificant, it is regarded as indicative of accumulation in commercial quantities nearby.

●

Pryor and Gerald M. Smith's No. 2 Wilson, in NE NW NW section 9-33s-6e, Cowley County, Kansas, pumped 30 bbl. of oil per hour on an 18-hour test from the Arbuckle limestone at a depth of 3514 to 3517 feet. This formation had not previously produced oil in Cowley County.

●

Noble Johnson's No. 1 L. A. Patton, in section 15, Indianola Survey, three miles north of Melvin, McCulloch County, Texas, produced 5,000,000 cu. ft. of sweet gas and seems to open a new gas field. It is three-fourths of a mile from the discovery oil well. Casing is set at a depth of 1420 ft. and the total depth is 1563 feet.

●

Richfield Oil Company's No. 1 Western Oil Company, one mile east of the Elk Hills field and two miles west of the Ten Section field, in the San Joaquin Valley, California, produced 7,000,000 cu. ft. of gas and some distillate of high gravity from a new zone, according to reports.

●

G. P. Shelton et al.'s No. 1 E. H. Sands et al., in section 86, Pauls subdivision, Nueces County, Texas, flowed gas and distillate through 1/8-in. choke from a sand at a depth of 4666 to 4675 feet. This zone had not produced in wells previously drilled. Tubing pressure was 1700 lb. and casing pressure 1800 pounds.

●

R. V. Tidwell et al.'s No. 1 W. T. Ivey, in the F. L. Green Survey nine miles west of South Bend, Young County, Texas, produced 50 bbl. of oil and 90 bbl. of water from a limestone at a depth of 3535 to 3550 feet. Casing was set at a depth of 3532 ft. and the limestone was treated with 8000 gal. of acid.

AVERAGE CRUDE PRICES

California	
Kettleman Hills	$1.19-1.43
Playa Del Rey	.80-1.16
Coalinga	.70- .90
Signal Hill	.80-1.21
Montana	.90-1.35
Wyoming	.35-1.30
Colorado	.92-1.25
New Mexico	.53- .95
Texas	
North Central	.71-1.13
Panhandle	.67-1.06
West Texas	.53- .95
Gulf Coast	.79-1.28
Darst Creek	.96
East Texas	1.10
Talco	.55
Kansas	.60-1.10
Oklahoma	.60-1.10
Arkansas	.66-1.05
Louisiana	
Rodessa	$ 1.05
Gulf Coast	.74-1.20
North Louisiana	.73-1.05
Illinois	1.05-1.15
Kentucky	1.10-1.40
Indiana	1.05
Ohio	
Lima	.90
Michigan	.74-92.5
Pennsylvania	
Bradford	1.68
Southwest	1.34
Eureka	1.28
Buckeye	1.18
Corning	.97
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in Barrels)

	[1]B. of M. Calculated Requirements (October)	Week Ended Oct. 29, 1938	Week Ended Oct. 1, 1938	Week Ended Oct. 30, 1937
Oklahoma	523,600	432,000	454,050	586,750
Kansas	163,400	157,100	159,400	185,600
Panhandle Texas	.....	60,100	68,250	79,000
North Texas	.....	79,800	71,100	73,200
West Central Texas	.....	31,850	28,750	34,700
West Texas	.....	200,200	189,750	217,350
East Central Texas	.....	90,550	89,150	110,200
East Texas	.....	370,050	369,000	482,950
Southwest Texas	.....	224,500	217,700	268,500
Coastal Texas	.....	203,600	202,600	204,900
TOTAL TEXAS	1,359,000	1,260,650	1,236,300	1,470,800
North Louisiana	.....	75,450	73,700	76,250
Coastal Louisiana	.....	194,200	186,900	167,750
TOTAL LA.	248,400	269,650	260,600	244,000
Arkansas	54,100	49,200	57,750	48,650
Eastern	148,400	183,800	181,900	133,300
Michigan	53,900	53,850	50,050	54,300
Wyoming	69,700	51,350	53,500	57,400
Montana	13,800	13,500	13,450	17,650
Colorado	4,300	3,950	3,600	4,150
New Mexico	109,200	103,500	105,800	103,350
TOTAL EAST OF CALIF.	2,747,800	2,578,550	2,576,400	2,905,950
California	619,000	659,000	655,400	697,000
TOTAL U. S.	3,366,800	3,237,550	3,231,800	3,602,950

[1]These are Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of October. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

Out in Front Again!

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Dowell *Red* Solvent is the result of extensive study of paraffin problems throughout the United States. It is a running mate to the highly successful Dowell Orange Solvent, formerly known as Dowell Paraffin Solvent, and was especially developed for more effective action on the less pure, or asphaltic paraffins.

Dowell *Red* Solvent has already proved itself in the field. Operators are enthusiastic over results. This new product is a knock-out—more effective than any other solvent now in use—with a much faster rate of reaction. Yet a smaller amount of material is required. And it does the job at lower cost because it comes in concentrated form and is diluted in the field.

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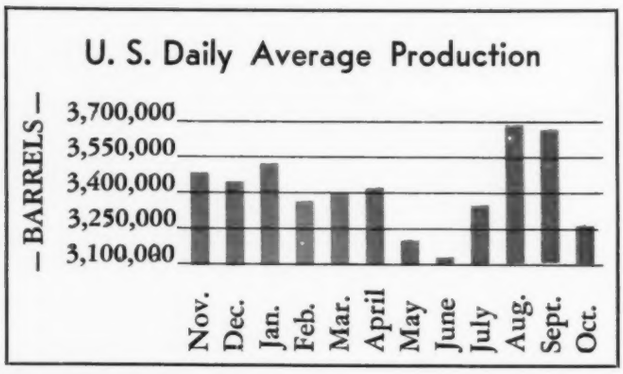
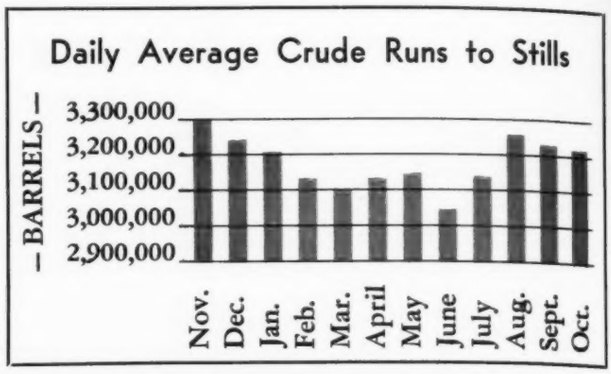
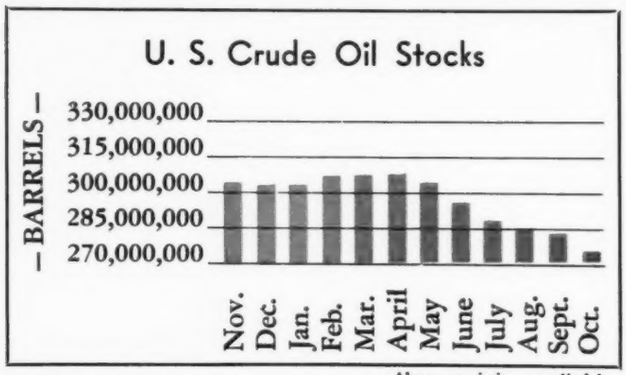
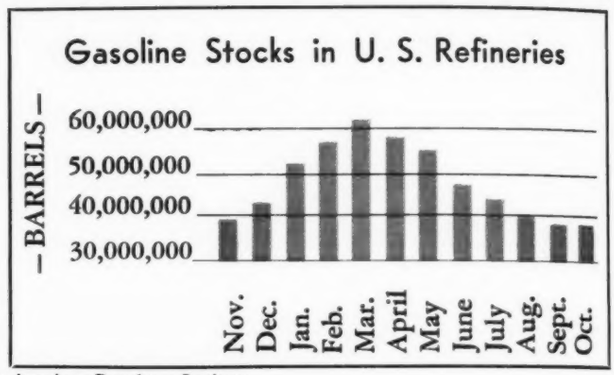
OIL AND GAS WELL CHEMICAL SERVICE

Summary of Petroleum Statistics and Field Activities









Above statistics supplied by the American Petroleum Institute.

Summarized Operations in Active Fields for October, 1938

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	109	107	15	32	3500-3700	2	40	Rotary
Duval County	63	50	6	23	1554-2900	2	22	Rotary
Ector County	47	47	4	64	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	47	45	32	125	1700-3900	2	40	Rotary
Refugio County	25	22	3	15	4900-5900	2	38	Rotary
Nueces County	27	25	6	19	3922-5878	2 or 3	21-54	Rotary
Winkler County	18	18	4	13	2850-3450	2 and 3	30-38	Rot.-Cab.
K. M. A. Field	53	49	34	40	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Oklahoma City	1	0	4	8	6450-6682	3	39	Rotary
Fitts Pool	13	11	2	5	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	15	12	3	23	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	18	16	2	15	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	25	24	3	21	3290-3518	2	39-42	Rot.-Cab.
LOUISIANA-TEXAS-ARKANSAS								
Rodessa	9	7	5	9	5950-6450	3	39	Rotary
ILLINOIS								
Central Illinois	233	194	55	374	2950-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	36	34	14	81	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	2	2	2	10	8300-8730	3 or 4	40	Rotary
Wilmington	15	15	4	15	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for October, 1938

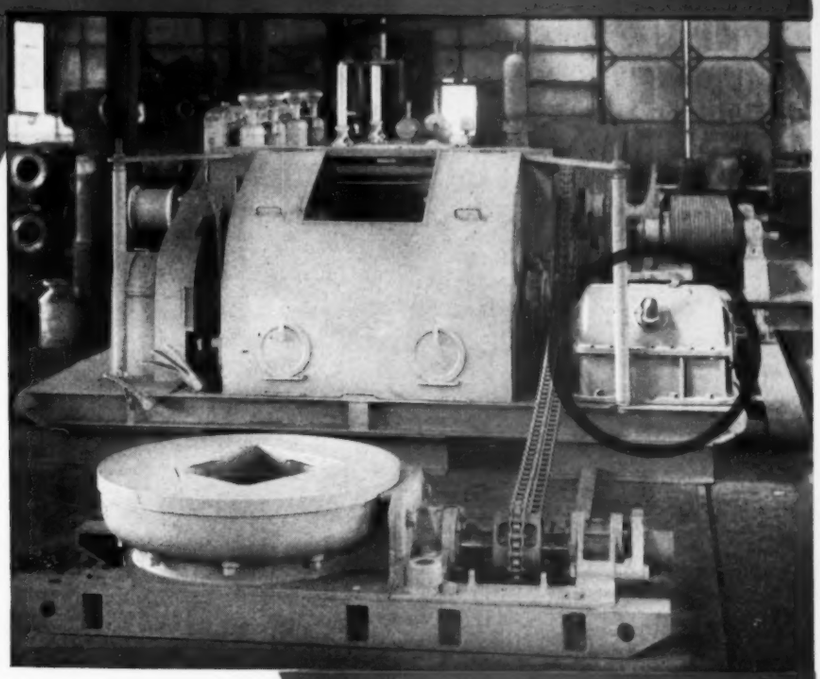
State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1937 (In Barrels)
	October	September	October	September	October	September	October	September	October	September	
Arkansas	21	16	20	13	17	19	14	15	34	36	12,088,341
California	100	124	83	107	83	112	95	96	207	209	238,587,663
Colorado	0	1	0	0	....	....	4	2	26	25	1,532,893
Illinois	233	255	194	199	....	....	260	**263	110	112	7,376,022
Indiana	28	17	20	13	....	....	3	5	42	45	820,000
Kansas	150	154	120	119	122	162	30	34	178	202	70,542,000
Kentucky	88	106	49	66	....	....	8	10	111	106	5,500,000
Louisiana	94	102	66	63	122	81	51	40	183	191	90,501,068
Michigan	113	115	64	66	85	141	20	25	106	130	16,254,181
Mississippi	3	....	1	....	....	....	5	6	3	3	Gas Prod.
Montana	11	6	9	6	....	....	4	4	52	56	5,775,000
New Mexico	45	42	41	37	....	....	16	15	116	131	38,642,184
New York	61*	42*	50	37	....	....	....	....	....	....	5,466,200
Ohio	70	102	49	75	....	....	37	46	113	120	3,547,600
Oklahoma	174	186	116	123	188	215	45	50	273	222	225,402,731
Pennsylvania	143*	163*	128	151	....	....	....	....	....	....	19,154,400
Texas	970	1012	745	780	798	1094	271	311	994	1154	506,891,233
West Virginia	76	64	70	52	....	....	25	27	124	126	3,833,000
Wyoming	13	6	8	5	....	....	6	5	63	59	19,402,121
Total	2393	2513	1833	1912	1415	1824	894	954	2735	2927	1,271,316,637

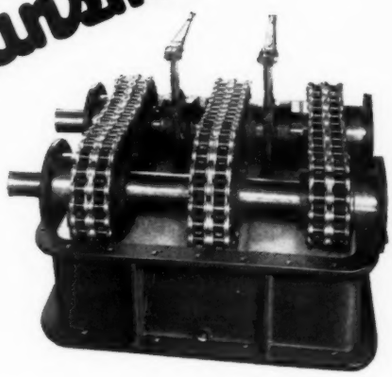
*Includes water-intake and pressure wells.
**Includes 64 rigging up and 199 rigs standing.

Multiple ROTARY TABLE SPEEDS

WITHOUT CHANGE OF ENGINE SPEED

WITH THE **GUMBO BUSTER ROTARY DRIVE transmission**





The conventional mechanical rotary drilling rig, using an ordinary 3 or 4 speed draw works, may now be modernized at comparatively small cost.

By adapting the Gumbo Buster Rotary Drive Transmission to commonly used types of draw works, compounded internal combustion engines may be operated at the most economical speeds for efficient slush pump operation, without reference to rotary table speed requirements—which are supplied (without varying the speed of the engines) through the transmission.

This provides operating flexibility which leads to lower fuel costs, longer engine life, better pump performance, and more service from drilling bits.

• *Manufactured by* **THE AMERICAN WELL & PROSPECTING COMPANY**
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HOUSTON
L. D. 203 Local "Cap" 1301

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ODESSA
L. D. 683 Local 684

FORT WORTH
Local and L. D. 3-3506

SHREVEPORT
L. D. 15 Local 6481

CENTRALIA, ILL.
Local and L. D. 589

TULSA
L. D. 681 Local 5-3204

OKLAHOMA CITY
L. D. 785 Local 7-2725

BARTLESVILLE
Local and L. D. 3410

WICHITA
L. D. 59 and 116
Local 2-1431 and 2-1432

AND
BRANCH STORES

Progress of Major Pipe Line Work

THE Magnolia Pipe Line Company is constructing a gathering system in the Lake Centralia field, Marion County, Illinois, consisting of 3-, 4-, and 6-in. laterals, and a ten-mile 8-in. main line to connect with the Illinois Pipe Line Company's trunk system. The line will be for the transportation of Magnolia Petroleum Company's production in the area to refineries of the Socony-Vacuum Oil Company, of which Magnolia is a subsidiary.

The Magnolia's line is the third from the new producing area of Illinois since the first of the new fields was brought in about 20 months ago. The Central States Pipe Line Company was organized by The Texas Company and a line is being completed from Salem to Lawrenceville. The Texas Company has a refinery at the latter point. The Oklahoma Pipe Line Company is transporting oil for the Carter Oil Company, the line having been completed only recently.

o

The Champlin Refining Company, Enid, Oklahoma, plans to construct a 25-mile pipe line from the new field recently opened by the company near Hillsdale, Garfield County, Oklahoma, to its refinery at Enid, it has been announced.

o

According to tentative plans the Mene Grande Oil Company, a subsidiary of the Gulf Oil Corporation, will lay a 16-in. oil line from the new Oficina field, eastern Venezuela, to Guanta on the Caribbean Sea, a distance of 100 miles. The route of the line would be north from Oficina to Cachama, Cantaura, Anaco, Caicaito, San Mateo, Guiamara, and to tidewater at Guanta. Pumping stations would be erected at Guanta and Oficina. As gravity flow can be utilized on a considerable part of the line only these two stations are deemed essential.

o

Recent figures reveal that 98 oil tankers totaling 826,660 tons were under construction at the end of September. Sixteen of the tankers totaling 142,349 tons are steam-driven, and 82 totaling 684,311 tons are motor ships. Great Britian and Ireland have under construction 27 of the tankers the tonnage of which is 228,913, the United States 13 of 118,099 tons, Germany 12 of 113,728 tons, and Holland 12 of 95,500 tons.

o

The General Petroleum Corporation has completed the laying of 13 miles of gathering lines in the Rio Bravo field, Kern County, California, to tie-in with its trunk line from the San Joaquin Valley to the Torrance refinery in the Los Angeles Basin. The Lang Company was the contractor.

The line is of 6⅝-in. O.D. pipe, manufactured by the Youngstown Sheet and Tube Company, and extends from the company's Rio Bravo tank farm to the Kern pumping station. A Gaso pump, motor-driven, is used to boost the oil from the field to the Kern station.

The line was coated over its entire length.

o

Work on the United Gas Pipe Line Company's new line from the Katy field, Waller County, Texas, to Houston is progressing rapidly and is expected to be completed in the near future. The line is being constructed of 8-, 10-, 12-, and 16-in. pipe and its total length is 47 miles. The 16-in. pipe is being coupled and the rest welded.

The Republic Production Company's 18-mile, 6-in. oil line from the Bancroft field, Beauregard Parish, Louisiana, to The Texas Pipe Line Company's Bunkie Hill pumping station across the Sabine River in Texas, has been completed and oil is being pumped through it. The Latex Construction Company, Houston, Texas, was the contractor.

o

John E. Edgerton, Lebanon, Tennessee, president of the Natural Gas Corporation of Tennessee, Inc., announces his company is planning the laying of a pipe line from a gas field near Shreveport, Louisiana, to Chattanooga. The principal purpose of the line would be to supply Chattanooga with gas, although laterals would be laid to supply natural gas to other cities and towns in the area.

o

The Mar-Tex Oil Company has purchased the Bennett Petroleum Company's pipe line from the Dickinson field, Texas, to Texas City, a distance of 14 miles. The line is of 4- and 6-in. pipe. It also serves the Gillock area.

o

The 22½-mile pipe line of Imperial Oil, Ltd., from East Kevin, Montana, to Coutts, Alberta, Canada, has been sold to LaRue Smith and associates of Great Falls, Montana. The line has been inactive since Imperial Oil, Ltd., discontinued purchasing Montana crude oil. In addition to the 22½-mile, 4-in. main line the property includes gathering lines, 387,000 bbl. of storage, and a pumping station in the Kevin-Sunburst field.

o

The Fitzsimmons field, Duval County, Texas, is being given its first pipe line outlet by the Humble Pipe Line Company. A 4-in. line 20 miles in length is being laid from the field to the company's Benavides pumping station. W. G. "Bill" Hanrahan, pipe line contractor, Dallas, Texas, is constructing the line.

Humble may also lay a line to serve the Flag Lake pool, Henderson County, Texas. According to tentative plans a 20-mile, 4- and 6-in. line would be laid from the field to Humble's Mildred station in Navarro County.

o

H. C. Price Company, Bartlesville, Oklahoma, announces it has been awarded the contracts for electric welding and either has started or completed construction on the following pipe lines:

From S. D. Bechtel Company, 140 miles of 8 in. for the Continental Oil Company in Wyoming.

From I. C. Little, gathering lines for the Carter Oil Company in Illinois.

From White Deer Pipe Line Construction Company, ten miles of 8 in. for the Illinois Pipe Line Company in Illinois.

From J. J. Connor Construction Company, 35 miles of 16 in. for the Northern Natural Gas Company in Iowa and Minnesota.

From Williams Brothers Corporation, 73 miles of 8 in. and 10 in. for the Central States Pipe Line Company in Illinois.

From S. D. Bechtel Company, 53 miles of 18 in. for the Mountain Fuel Supply Company in Wyoming and Utah.

All the lines are being electric welded using the Fleetweld process.

THE Petroleum Engineer

NOVEMBER, 1938

Coöperative Pressure-Maintenance Project in Billings Pool, Oklahoma, Includes Operation of Gasoline Plant

Though owned by several companies, properties are operated as a unit, one participating company producing the wells and another operating the jointly owned high-pressure absorption gasoline plant

By E. O. BENNETT
Chief Petroleum Engineer, Continental Oil Company

THE first pressure-maintenance operation in Oklahoma in which the pressure exceeds 1000 lb. per sq. in. has been inaugurated in the Billings pool in Noble County.

The Billings pool was discovered in February, 1917, when Mid-Co Petroleum Company's well in section 22, T-23-N, R-2-W, produced 250 bbl. of oil per day from the Hoover sand at a depth of 2121 to 2136 feet. This well was located on the crest of an anticlinal dome, as mapped from surface outcrops. After the development of the pool, subsurface mapping on the Pawhuska limestone, found at a depth of 2000 ft., revealed a dome having a diameter of one mile and a closure of 160 feet.

During the development of the Hoover sand, several wells were deepened to the Ordovician formation (Lower Simpson and Arbuckle). A study of the records of these wells revealed that this structure had been elevated in early Pennsylvanian time, that approximately 650 ft. of sediments, including formations of Mississippian and Upper and Middle Ordovician age, had been eroded, and that the truncated edges of these formations had been overlapped by the Cherokee shale. It was assumed that oil was trapped in the truncated edge of the Wilcox sand on the flanks of this dome.

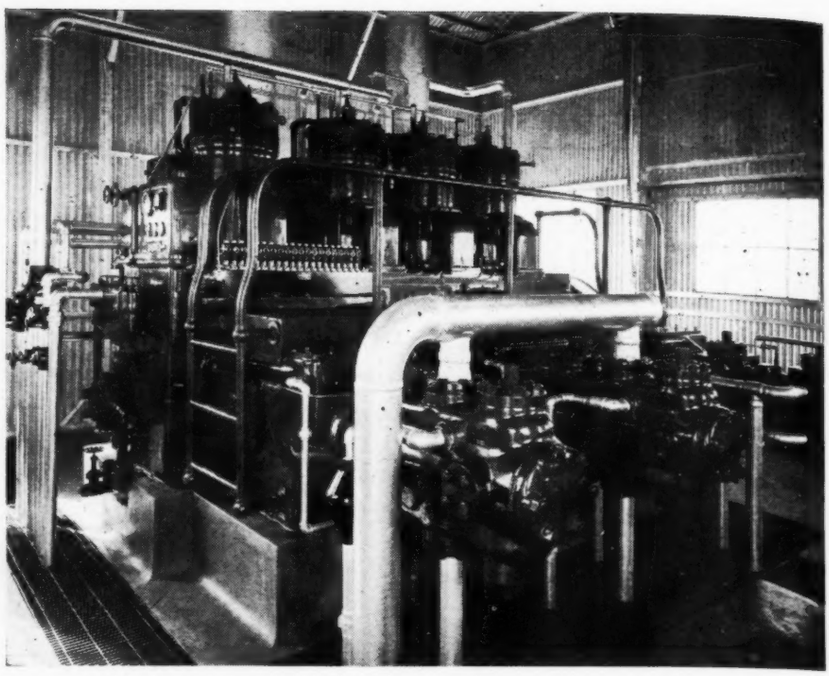
On May 20, 1936, oil was obtained from the Wilcox sand by Phillips-Shell, when their No. 2 O'Neil, in SW SE SE of 16-23n-2w, was completed producing 3561 bbl. of oil per day from a depth of 4225 to 4254 ft., the initial bottom-hole pressure being 1664 lb. per sq. inch.

Information about the structure of the Pre-Pennsylvanian formations is incomplete at this time, but the structure appears to be a tilted block faulted on the southeast side. Wilcox production

In the Continuous Tables section of this issue appears an introductory article explaining the Decimal System of Classification for the filing of petroleum engineering literature, as devised and extended from the Dewey Decimal System by Professor Lester C. Uren, head of the Petroleum Engineering Department, University of California. The entire index in detail and a complete alphabetical index of subjects will be published in consecutive issues of THE PETROLEUM ENGINEER.

Publication of the Uren Classification in this convenient form is rendered as a service to our readers in response to their many requests for information on the Decimal System now used on the tables in the Continuous Tables section.

400-hp., 2-stage compressor. Note simplification of piping and curved concrete base

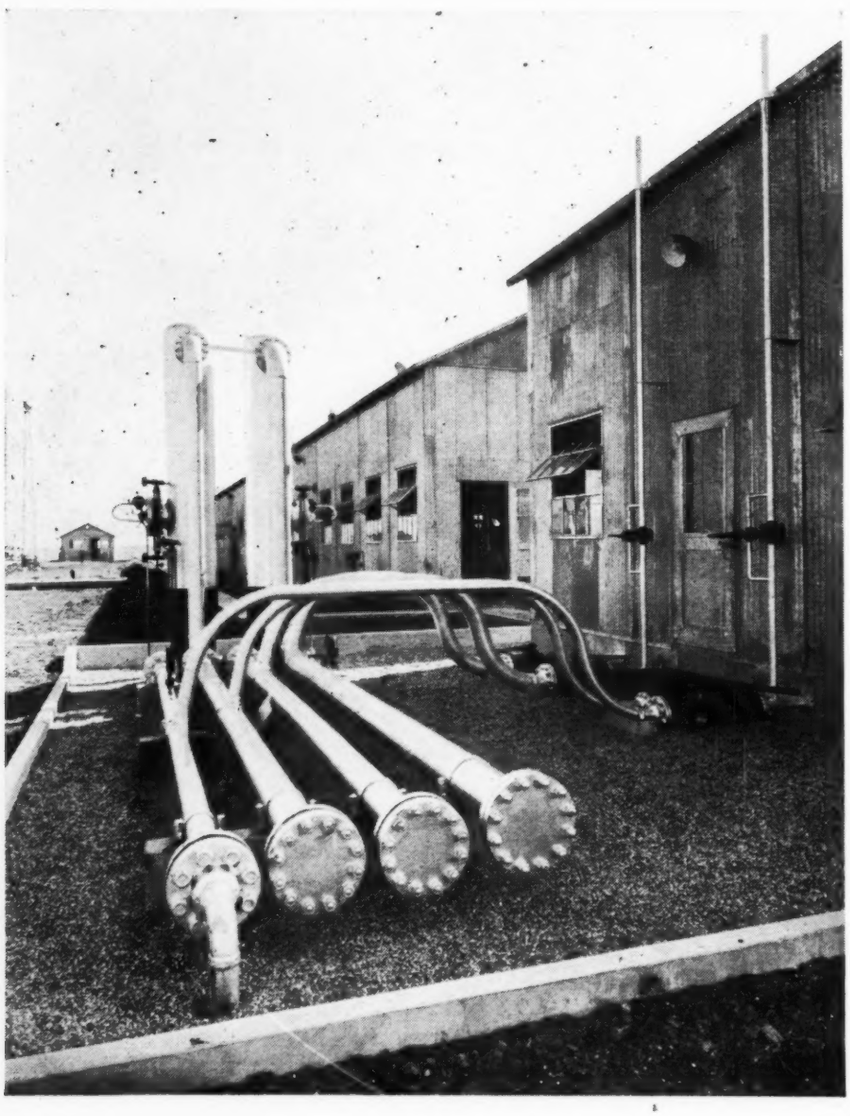


has been developed on the west and southwest flanks of this faulted dome. Dry holes have limited the production on the north end, and the fault limits the production on the south and east flanks.

The field was developed in an orderly manner by wells spaced on a regular 10-acre pattern. By October 1, 1938, 64 wells had been completed, and a total of 3,998,192 bbl. of oil had been produced.

The energy for flowing wells in the Billings pool is obtained partly from gas under pressure at the crest of the structure and partly from gas in solution, but mostly from water encroaching at the flank of production along the entire lower edge of the pool.

Realizing that the Billings pool should be classed as a water-drive pool, and that if properly controlled would yield a high ultimate recovery, Continental, Phillips-Shell, and Tidewater Oil Company engineers studied the possibilities of instituting a pressure-maintenance program.

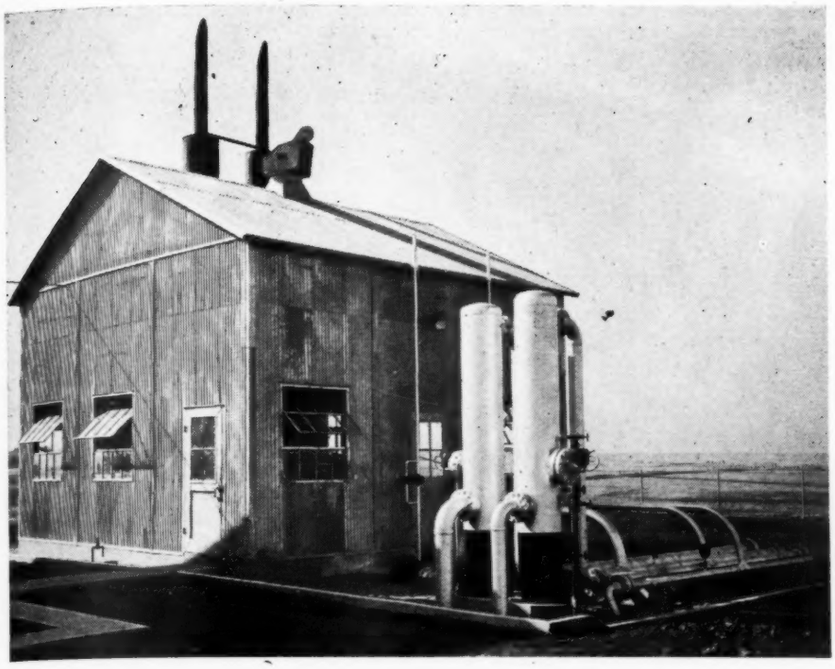


A careful analysis and survey indicated that the return of 4,000,000 cu. ft. of gas per day, the total amount available from the gasoline plant in the pool, would retard the "fingering-in" of edge water and greatly reduce bottom-hole pressure decline. Water entering the edge of the structure along a uniform front was deemed to be very conducive to increased ultimate recovery.

After the geological and engineering surveys were completed a unit plan of operation was developed and placed in effect. The producing operations for the unit, which comprises the properties of the above-named companies, are being conducted by Phillips Petroleum Company.

The jointly owned gasoline plant began operations in February, 1938, under the management of Continental Oil Company. The gasoline plant is of the high-pressure absorption type. Gas is taken from separators at 6 in. of vacuum, and compressed through two stages to 300 pounds. Considerable care was taken to collect all plant and

Headers and scrubbers on low-pressure intake and intermediate-pressure intake; valves and check valves on lines from compressor cylinders to headers. Note safety heads and by-pass lines on discharge lines



Exterior of compressor plant. Note tube turn and welded construction throughout

residue vapors so that the shrinkage loss through it would be maintained at a minimum. The design of the gasoline plant was planned to minimize the total cost of constructing the plant and installing any additional equipment necessary to provide residue gas at high pressure for sale or for pressure maintenance, should either of these requirements develop. The efficacy of the design was indicated by the relatively small cost of the addition of the pressure-maintenance equipment to return gas to the sand. The absorber is operated at 300 lb. per sq. in. and after the condensable fractions are removed from the gas the dry residue gas flows to the pressure-maintenance unit.

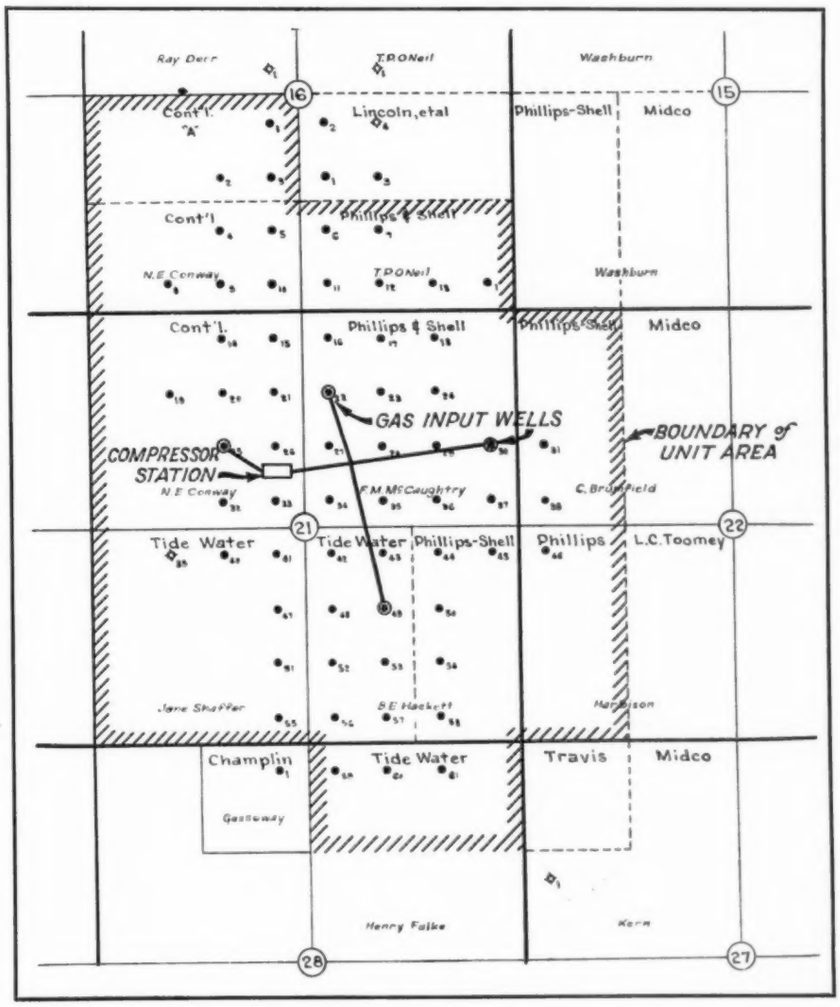
The pressure-maintenance plant is erected adjacent to the gasoline plant and is operated by Continental Oil Company. The compressor unit consists of one Clark Brothers Company 400-hp. angle type, two-cycle, engine-driven compressor to compress the gas from 300-lb. pressure to a pressure of 1600 lb. or more. The gas is now being returned to the formation at a pressure of 1415 lb. per sq. inch. The weight of the gas column in the input well makes the difference between the input pressure of 1415 lb. and the formation pressure of 1560 lb., plus the differential pressure necessary to cause flow from an input well into the formation.

Four input wells are used for the distribution of the gas throughout the pool. The proven area of the Billings pool is 640 acres, although the unit contains 1120 acres. The average gross gas/oil ratio for the pool is 840 cu. ft. per bbl., of which approximately three-fourths will be returned, making the net gas/oil ratio slightly in excess of 200 cu. ft. per barrel.

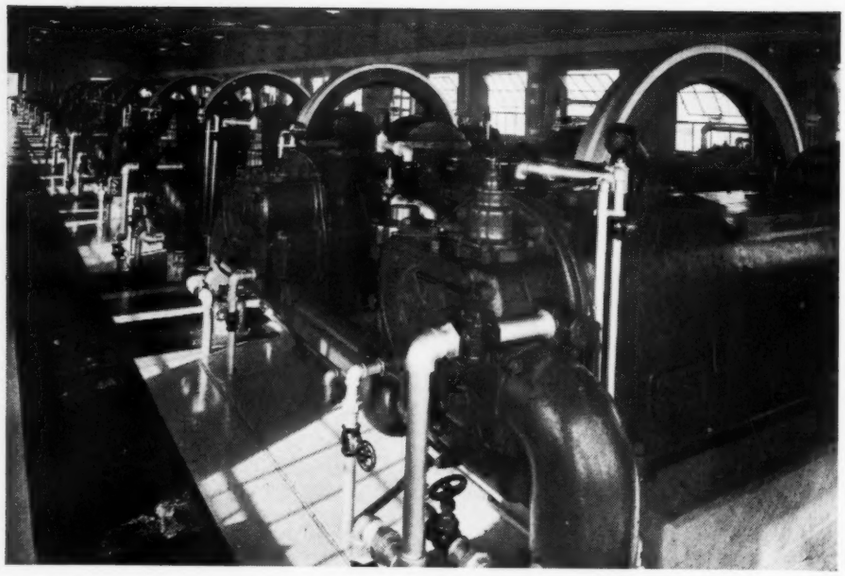
Prior to the installation of pressure-maintenance machinery, Billings pool operators held production to a moderate rate, which kept edge water from "fingering-in" to trap oil.

From the inception of production the pool has been one of the most efficiently operated in the state of Oklahoma. The total pressure drop has been only 98 lb. during the production of a cumulative total of 3,998,192 gross barrels. Approximately 40,800 bbl. has been produced per lb. of pressure drop.

Return of gas to the producing formation in the Billings pool and production at a rate suitable to prevent the uneven encroachment of water will result in an ultimate recovery much larger than could otherwise be ob-



Plat of Billings Pool, Noble County, Oklahoma



Interior of compressor room

tained. The cost of producing the oil will be less than that for most similar pools on account of the extremely slow rate of dissipation of reservoir pressure, which will make pumping unnecessary, and because unit operation will reduce supervisory expense.

Field lines are welded 2-in. and 3-in. seamless steel pipe. Meters are installed at each input well on a run just off the derrick floor. All input wells are equipped with Tepetate-type check valves to prevent a wide-open flow in the event of line failure.

Vertical expansion loops are erected in the lines about 1100 ft. apart. The difference between final temperature of compression and extreme outdoor winter temperature will exceed 200 deg. fahrenheit.

All headers at the plant are elevated above normal grade and plug cocks are used in place of valves throughout. All lines and fittings on the high-pressure discharge side were tested to a pressure of 3000 lb. per sq. in. with cold water.

Safety devices are installed in the engine lubricating-oil circuit and water circuit. An intake scrubber equipped

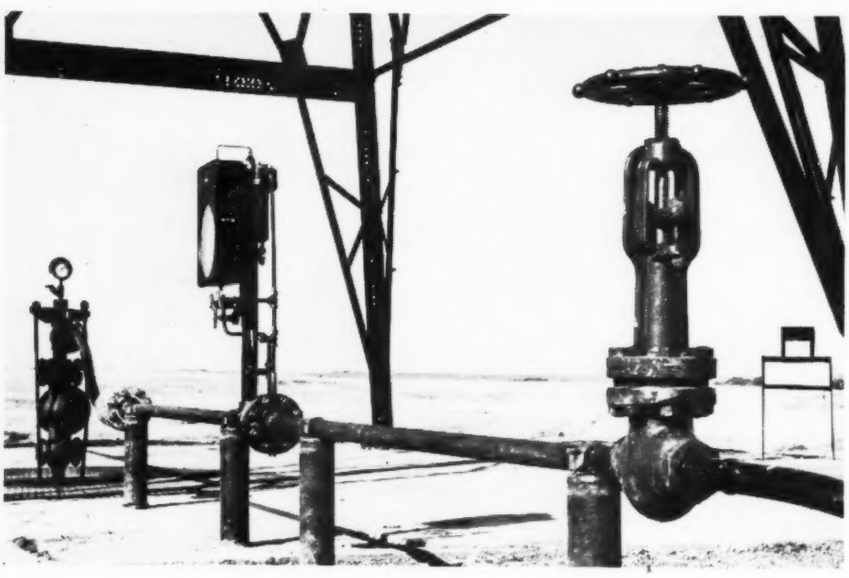
An expansion loop on a field line

with a float-operated mercoid switch prevents liquid from the gasoline plant entering and injuring the intake compressor cylinders. Should a volume of liquid be received, the mercoid switch will close a circuit shortcircuiting the magneto and stopping the engine.

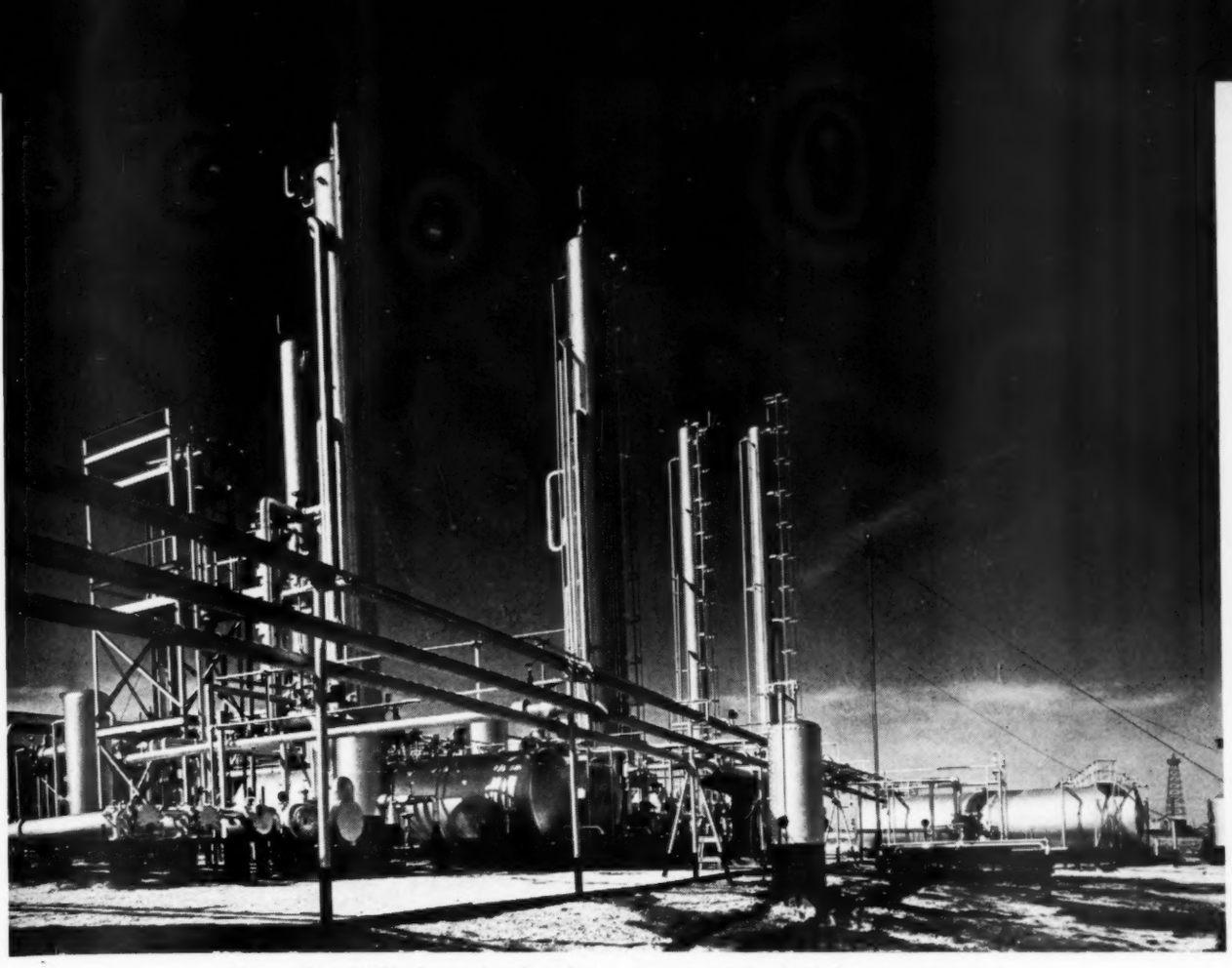
Frangible disc-type safety heads are used for protection against excessive pressure at all parts of the plant.

The beneficial results of returning gas to the Wilcox sand will be shown by the Billings pool operation, and the acre-foot recovery is expected to be much greater than that obtained from Wilcox formation pools where gas was dissipated without regard to its value for producing additional oil.

Present trends in production practice indicate that more companies are giving consideration to the saving of reservoir energy by the return of gas to the producing horizon.



Input well equipped with flow regulating valve, orifice meter, Tepetate-type check valve and wellhead connections



Absorption-distillation unit after being revamped for high butane recovery

High Butane Recovery by High-Pressure Absorption

Discussion of the design and operation of an East Texas natural gasoline plant wherein 95 percent butane recovery is being obtained

By FRANK G. NOBLE

Process Engineer, Natural Gas and Gasoline Department, Humble Oil and Refining Company

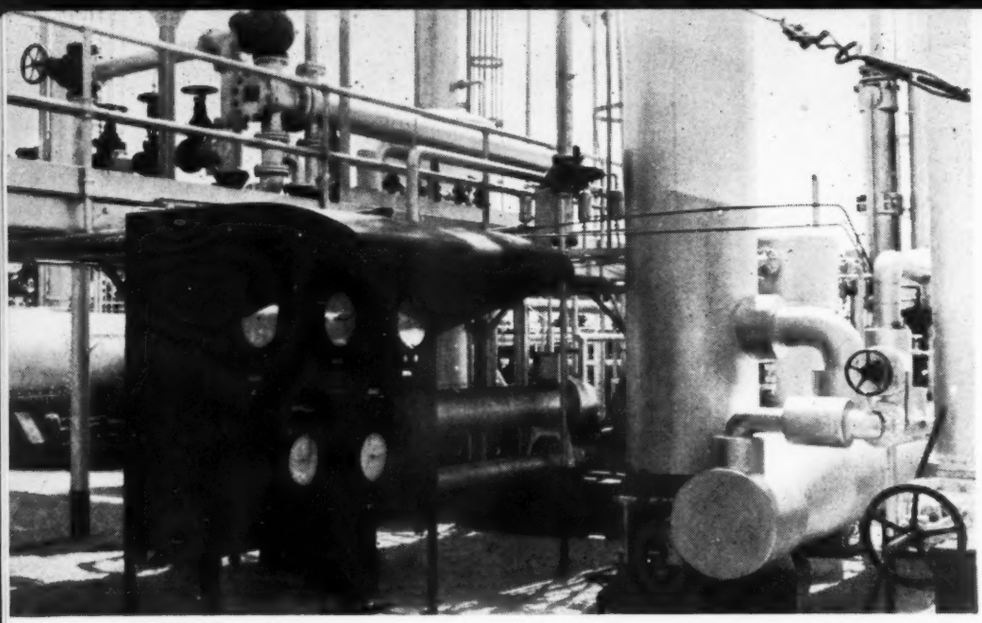
IN the East Texas Field there are three distinct types of gasoline plants operated for high butane extraction: (1) high-pressure absorption, (2) combination of low-pressure absorption and refrigeration, and (3) vapor rectification and refrigeration. Because of the potential butane in the wet gas most East Texas gasoline plant operators have revamped their plants for high butane recovery. It is of interest at this time to discuss the high-pressure absorption process for butane extraction used at the Humble Oil and Refining Company's Kilgore plant two and one-half miles southwest of Kilgore in Rusk County, Texas.

The present plant is a combination two-stage compression and high-pressure oil-absorption type, the absorption and distillation unit being designed for 95 percent butane recovery. The original plant was designed and constructed in 1931, operating as a two-stage compression plant. As more wells were connected to the plant, the need for a high-pressure absorption unit became apparent; therefore, in 1933 absorption equipment was installed, and it remained in operation until 1937, at which time it was revamped for high butane recovery.

The field gathering system serving 989 wells consists of 32 miles of pipe ranging in size from 2 in. to 16 inch. Gas is brought through four main lines, which permits 12-in. vacuum compressor suction and eliminates pressure on the field system. The plant has a daily capacity of 8,250,000 standard cu. ft., but owing to proration and the methods of producing wells the gas load varies, the average volume processed by the plant being 6,500,000 cu. feet. A system of flow schedule control combined with sufficient plant capacity to handle the peak gas loads keeps the plant and field operations well balanced.

Compressor Plant

The compressor plant consists of five single-cylinder, 4-cycle; seven twin-cylinder, 4-cycle, and three twin-cylinder, 2-cycle engines direct-connected to double-acting compressor cylinders. Ordinarily the low-stage en-



Control board in the absorption-distillation area

gines operate at a suction of 12-in. vacuum and 38-lb. discharge, the discharge gas being cooled in four horizontal coolers and any condensate removed in a low-stage accumulator before the gas is returned to the suction of the high-stage compressors. At 305-lb. pressure the discharge gas is passed through three vertical high-stage gas coolers where the gas temperature is reduced and considerable condensate formed. The liquid is separated from the gas in a 36-in. by 8-ft. high-pressure separator and both streams are further processed through the absorption-distillation unit for the recovery of desirable hydrocarbons.

Absorption-Distillation Unit

The flow sheet (Fig. 1) indicates the flow of the various streams in the absorption-distillation unit. As the flow is somewhat complicated, the following discussion may be helpful in its analysis.

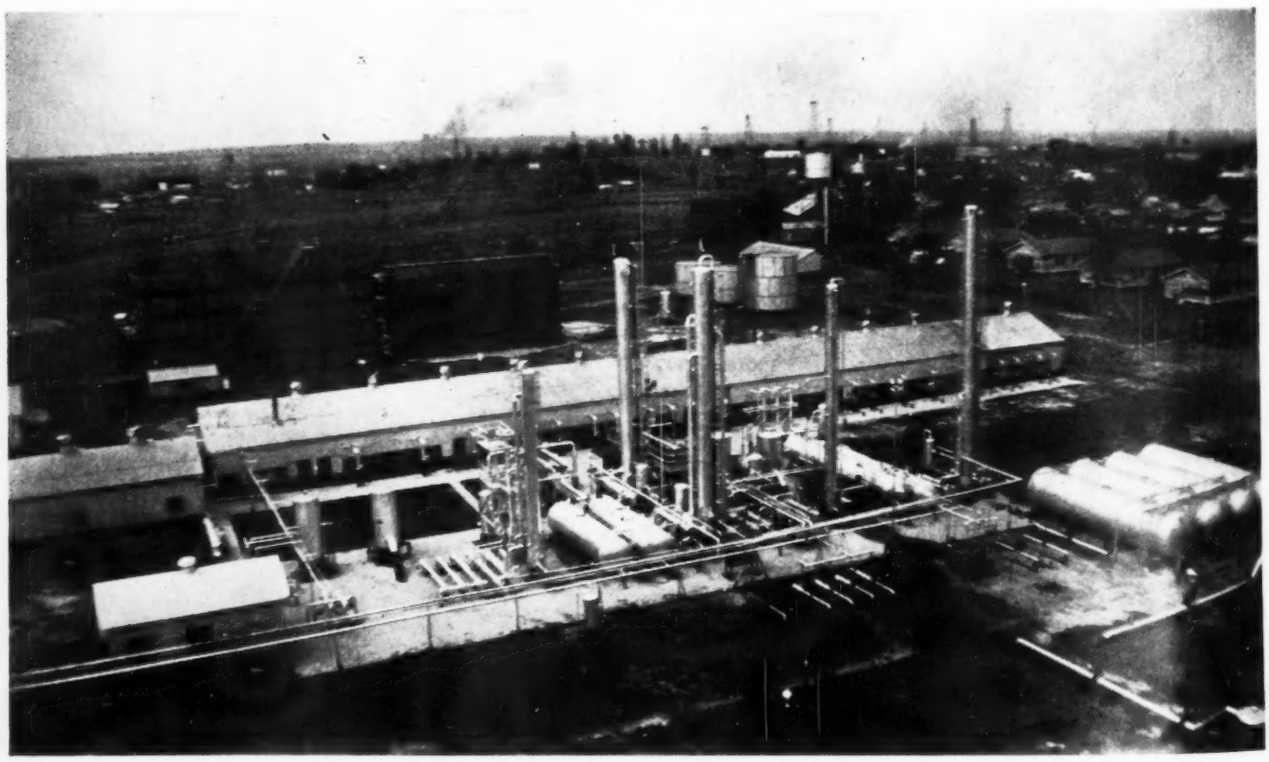
Starting from the high-pressure accumulator on the downstream side of the high-stage gas coolers, the gas is delivered to a 36-in. by 64-ft., 24-tray absorber operating at 300-lb. pressure. Several points of interest are noted in the absorber hook-up; (1) absorption of a rich gas at high pressure, (2) the use of four water intercoolers to restrict the temperature rise of the absorption oil to a minimum, and (3) the installation of controls to maintain a constant gas/oil ratio to the absorber. The four intercoolers are so situated on the absorber that each cooler has approximately the same heat load and maintains a nearly uniform temperature throughout the unit. An internal by-pass arrangement in the absorber permits the shut-down of any intercooler for cleaning or repairs without materially affecting the plant operation. Water from these intercoolers is used for further cooling in the two horizontal still vapor condensers.

The absorber residue gas is utilized in the field residue and gas-lift systems, for water-well operation, and as plant fuel.

Rich oil from the absorber is vented into a 36-in. by 8-ft. vent tank operating at a pressure of 130 pounds. Vapors from this vent tank pass to a 30-in. by 52-ft., 22-tray stripper still operating at 90-lb. pressure, and the remaining or unflashed rich oil from the vent tank is pumped by a turbine-driven centrifugal pump through three stripper heat exchangers and a preheater into the stripper still.

The stripper still differs somewhat from the ordinary still used in gasoline plants. In this unit the dissolved hydrocarbons in the feed plus a small amount of absorption oil are stripped overhead by means of stripping steam entering the bottom of the tower. A reheater in the lower section of the

Aerial view of Kilgore gasoline plant



stripper maintains a high bottom temperature. The vapors from the rich oil vent tank are introduced by a connection provided in the return line from the reheater. No reflux is required as the rich oil feed enters the top section of the stripper. From the stripper the overhead material enters a vapor-to-oil heat exchanger (rich oil from the reabsorber) and passes through two vertical stripper condensers into a 36-in. by 8-ft. accumulator. Both the liquid and the vapor product from the stripper accumulator flow to a vapor-liquid separator, where the vapors are separated and combined with the gas streams from the gasoline vent tank and still accumulator for metering. After being metered the gas joins the liquid from the vapor-liquid separator to form the total reabsorber feed. Vapors from the gasoline flash tank entering the feed are obtained by flashing the high-stage separator liquid from 300 lb. to 130 lb. pressure. The flashed vapors pass through a back-pressure regulator directly to the reabsorber feed.

In this process the reabsorber acts to a great extent as a control unit; that

TABLE I
Typical Plant Analyses and Data

HYDROCARBON ANALYSES

	Inlet Gas, Percent Vol.	*Absorber Residue, Percent Vol.*	*Finished Gasoline, Percent Liq. Vol.*
Methane	44.58	68.80	------
Ethane	15.62	17.73	------
Propane	22.40	13.05	4.57
Iso-Butane	3.02	.42	9.68
N-Butane	9.33	------	53.05
Iso-Pentane	2.06	------	11.31
N-Pentane	1.36	------	9.16
Heavier Plus	1.63	------	12.23
	100.00	100.00	100.00

DAILY QUANTITIES

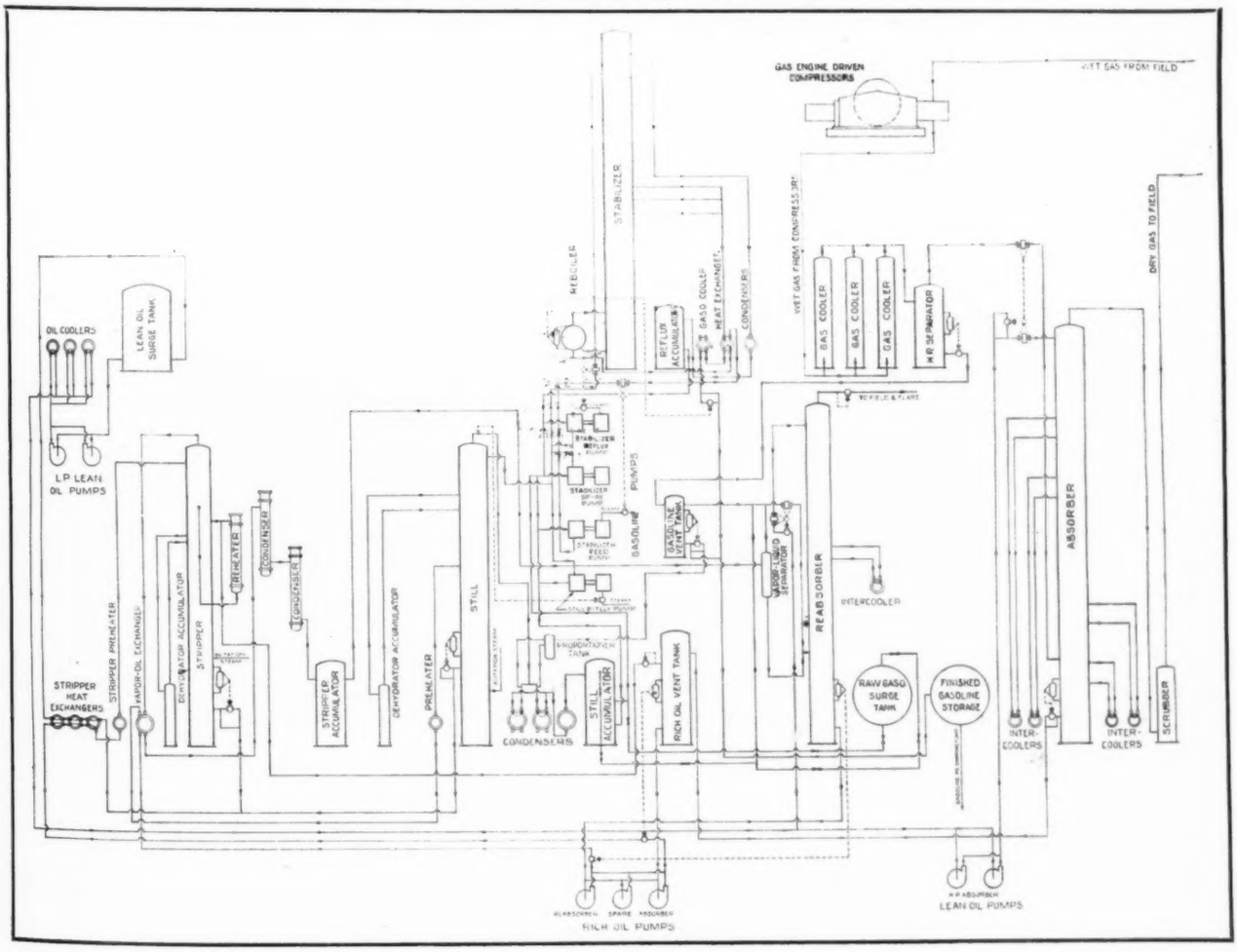
Gal. per minute absorption oil (30 deg. A.P.I.-214 Mol. Wt.)	69
Average gas volume	6,500 M cu. ft.
Total gasoline and B/P product*	38,750 gal.
Gal. per M cu. ft.	5.96

*Product containing propane equivalent to 10 percent of the butanes above 26-lb. Reid vapor pressure.

UTILITIES

Compressor hp.	2,200
Cooling water (total) gal. per minute	2,500
Boiler hp.	264
Auxiliary hp.	320

Fig. 1. Flow diagram of Kilgore gasoline plant



is, with the three different feed materials mentioned, a variation in the oil rate permits a flexible control of the finished gasoline obtained. This control is maintained by keeping the desired gas-oil ratio constant. The reabsorber is a standard 30-in. by 50-ft., 22-tray tower with one intercooler. It operates at a pressure of 85 lb. and the back-pressure regulator on the residue gas line leaving the reabsorber also controls the back pressure on the still and stripper still at 90 pounds. This pressure drop is due to pressure loss through inter-connecting lines. A steam-driven centrifugal pump delivers the reabsorber rich oil through the stripper still vapor-to-oil exchanger, a still preheater, and into the main still.

The main still is a 36-in. by 52-ft., 22-tray combination still and rectifier equipped with a reheater in the lower or stripper section. The total still overhead material enters two horizontal condensers, where the liquid from the gasoline flash tank is introduced through a proportioning tank. The total product then passes through a final sub-cooler and into a 36-in. by 8-ft. still accumulator. The still accumulator liquid product passes into a 6-ft. by 40-ft. stabilizer raw gasoline surge tank, and the vapors are returned to the reabsorber. Lean oil from the still is combined with the lean oil from the stripper still and passed through the three stripper heat exchangers into the lean oil surge tank. From this tank the oil is pumped by a turbine-driven centrifugal pump through two lean oil coolers to the reabsorber and likewise to the suction of the 300-lb. absorber lean oil pumps. This completes the cycle of absorption oil through the plant.

Raw gasoline from the 6-ft. by 40-ft. surge tank is charged by a reciprocating pump through a heat exchanger into a 36-in. by 51-ft., 30-tray stabilizer operating at 250-lb. pressure. The stabilizer overhead vapors pass through a condenser into a 36-in. by 9-ft. accumulator. The level and temperature in this tank are controlled by a regulator in the water line from the condenser, thereby eliminating excess reflux. The non-condensed vapors are utilized in the field residue system.

The finished gasoline stabilizer bottoms go through the heat exchanger and a final gasoline cooler into a 6-ft. by 40-ft. finished gasoline storage tank. From this tank deliveries are made to the pipe line.

Boiler Plant

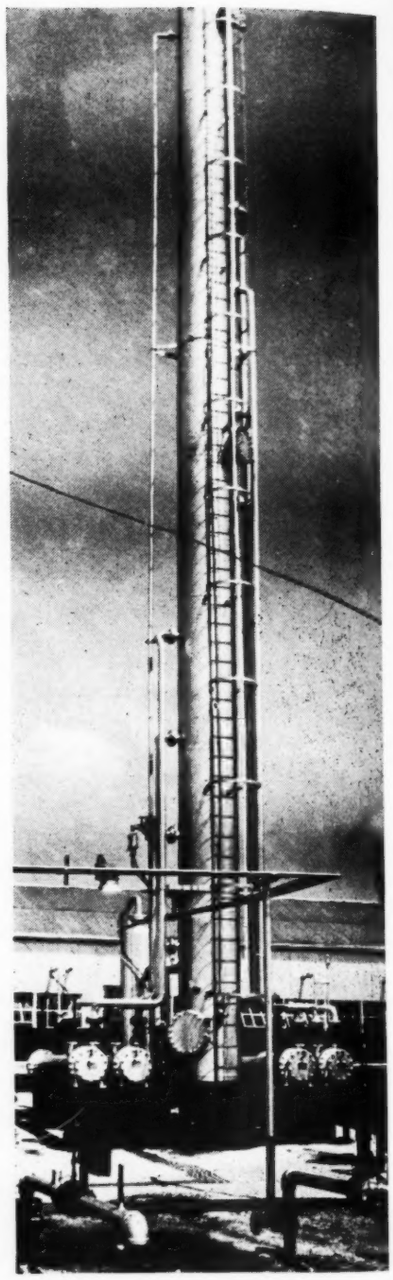
Steam for the distillation unit and pumps is generated at 150-lb. pressure by four oil-field type boilers that have a total boiler horsepower of 264. The boiler plant is so designed that any three boilers will provide ample steam while the fourth boiler serves as a standby. Exhaust steam from the pumps of the distillation unit is utilized in an open type boiler-feed-water heater, raising the temperature of the feed water to 210 deg. fahrenheit. The boilers are equipped with the usual safety equipment, such as high- and low-water-level alarms, steam snuff lines, and automatic control of feed water and fuel.

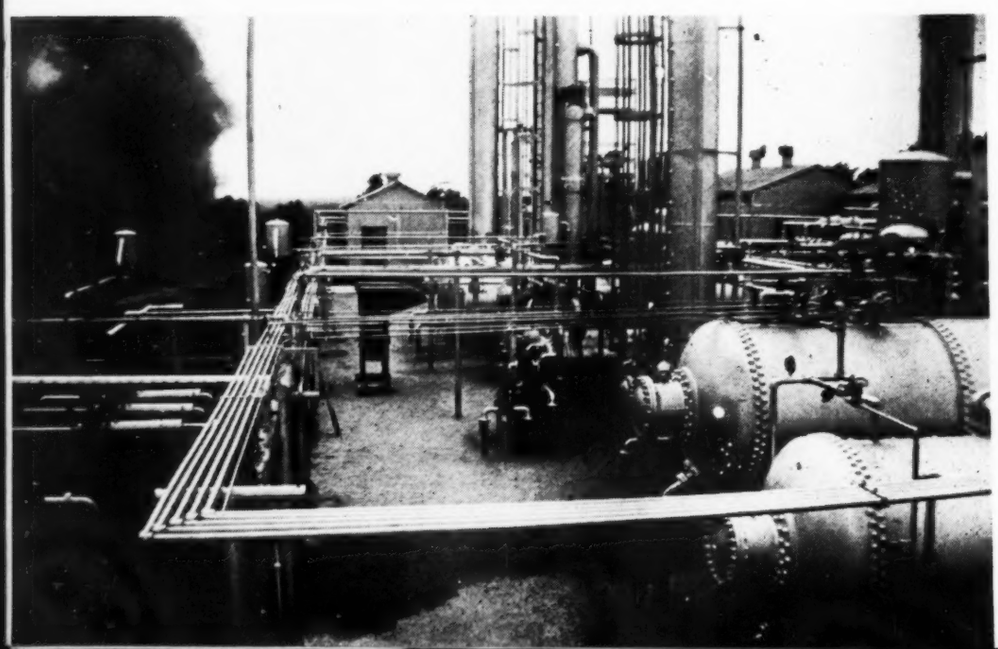
Auxiliary Equipment

Power for auxiliary equipment is produced by two 160-hp. vertical 3-cylinder, 4-cycle gas engines. These engines are direct-connected to generators, which provide power for water pumps, lights, etc. One unit operates continually and the other serves as a standby. All pumps in the water system are provided with electrically-driven standby units. All distillation unit pumps are steam-driven and are also provided with steam-driven standby units. Cooling water for the distillation unit is maintained at a temperature of 85 deg. fahr. or less by a 12-ft. by 60-ft. by 35-ft. redwood cooling tower, and a 12-ft. by 78-ft. by 43-ft. redwood tower cools the water for the compressor gas coolers and engine jackets. The water system is so arranged that either tower may be taken out of service.

The contractor designing and revamping the absorption-distillation unit received the coöperation of the personnel of the Natural Gas and Gasoline Department of the Humble Oil and Refining Company.

The absorber, which operates at 300-lb. pressure





Raw gasoline surge tanks in foreground, absorption-distillation unit in background

Electric Energy Consumption In Rotary Drilling

Data on power requirements discussed cover a five-year period and operations involving a total drilling footage in excess of 848,000 feet, or 160 miles

By W. H. STUEVE*

SO many inquiries have been made concerning the power requirement and possible cost of alternating current supplied by power utility companies for the drilling of oil wells that a study of the proper utility company records and oil company drilling logs has been made in order to assemble and present such data to the petroleum industry.

The equipment used for drilling the wells studied in this survey consisted of all makes and sizes, from two 25/65-hp. motors to a single 250-hp. motor on the drawworks. Likewise, the mud pumps ranged in size from 150 hp. to 250 horsepower.

This survey does not disclose the size of the motor used on the individual wells drilled. It is assumed that the drilling contractors used such machinery as was available in any locality in order to avoid the expense of transportation.

The data contained in this survey were obtained from the books of a large utility company operating in the Mid-Continent oil fields. Although the data represent only a small number of the total wells drilled in that territory the total drilling footage represented exceeds 160 miles, depth of the fields ranging from 2000 ft. to 7000 feet. The depth of the deepest well drilled by a-c. power from utility lines converted to d-c. power is 11,084 feet.

In recent years there has been much interest in the use of direct current generated at the well site, the desirable torque and speed characteristics of this form of power being similar to those of steam power.

As a consequence, few if any drilling rigs driven by a-c. motors have been built in recent years, so that, compared with the number of steam- or internal-combustion-engine rigs available, there are today few a-c. rigs in satisfactory repair. A factor tending greatly to discourage the use of a-c. rigs is the remoteness of most well sites from existing power lines.

Despite these supposed handicaps, some drillers still prefer a-c. equipment when power is available and are getting results using such drilling equipment. Probably the advantage of taking electric power at greater than motor ratings for short periods of time instead of being limited to the maximum capacity of a prime mover when pulling drill pipe or performing other operations of a similar character tends to offset the apparent advantage of finer speed control possible when d-c. or steam equipment is used.

The figures representing energy sales for drilling operations by a-c. rigs were obtained from annual reports of the power utility company. (Table 1). The energy sales are divided according to the depths drilled, and the number of wells in each group drilled during each year is shown. The depths are shown in round numbers, no attempt having been made to correct for small discrepancies due to surface contour, actual depth of the producing zone, or other factors that might affect the total power input slightly. Energy used for drilling-in by electrically driven cable-tool equipment is not included. Most wells, however, were drilled-in the last 50 or 100 ft. by steam power.

This information is plotted (Fig. 1) as "Rotary Drilling Depth in Feet" vs. "Total A-C. Energy in Kilowatt Hours Sold." To the right of the symbol for each year is shown the number of wells drilled during that year.

No attempt has been made to indicate the wells consuming maximum or minimum power. Thus, although wells drilled to a depth of 4200 ft. required an average of 93,876 kw-hr., a few are known to have consumed as much as 140,000 kw-hr. and a few as little as 75,000 kw-hours. It is almost impossible to determine the reason for this difference unless the details of formations drilled and fishing jobs attempted are available. Some crooked holes are drilled, whipstocks are used to straighten holes, and tools and drilling bits become stuck requiring slow milling operations, all of which will distort the resultant data. On the whole, however, the "average curve" from Fig. 1 may be used for close approximation.

The average curve of Fig. 1 can be extended to determine the energy required in drilling beyond a depth of 7000 feet. The deepest well drilled by a-c. power, mentioned previously, was the second Binger Well in Oklahoma, which required approximately 950,000 kw-hr. for drilling to a depth of 11,084 feet. Quantities of a-c. energy required for drilling to various depths intermediate between 7000 ft. and 11,000 ft. are interpolated (not extended in Fig. 1) as follows: 8000 ft., 330,-

TABLE I

Approximate depth in ft., number of wells drilled, total kw-hr. sold, and average kw-hr. per well (Rotary drilling)

Approximate depth, ft.	*Number of wells drilled, 1933 to 1937*	*Total footage drilled*	*Total kilowatt-hours sold*	*Average requirements, kw-hr. per well*
2000	30	60,000	1,136,469	37,882
3000	2	6,000	130,400	65,200
3375	1	3,375	60,100	60,100
3910	7	27,375	749,900	107,100
4200	92	386,400	8,636,551	93,876
5200	37	192,400	5,322,180	143,843
6500	14	91,000	2,889,200	206,371
6800	9	61,200	2,004,640	222,738
7000	3	21,000	745,080	248,360
	195	848,750	21,674,520	

*Engineer, Oklahoma Gas and Electric Company, Oklahoma City, Oklahoma.

000 kw-hr.; 9000 ft., 440,000 kw-hr., and 10,000 ft., 600,000 kw-hours.

As stated previously, no attempt has been made to analyze the results of this survey with respect to size of equipment used on the wells drilled, because the efficiency curve for all the motors is fairly flat between one-half and full load, and the difference between the power input for two 65-hp. motors fully loaded on the drawworks and the power input for a 150- or 200-hp. motor at three-fourths or one-half load on the drawworks motors is negligible.

No doubt the drilling of different formations requires very different amounts of power at different drilling depths.

It is generally conceded that as wells become deeper less footage is drilled per day, and more power is required per foot drilled, owing to increased friction on the drill pipe and higher mud pump discharge pressure.

Fig. 2 shows by data obtained in typical Oklahoma fields the increase in kw-hr. requirements as the well depth increases. The points for the "Oklahoma City" curve are the average for six wells in widely scattered locations, all drilled with rotary tools to a depth of approximately 6500 feet. The average total energy input was 290,000 kw-hr. per well, or an average of 45 kw-hr. per ft., but drilling of the last 500 ft. required 98 kw-hr. per ft., and the first 500 ft. only 8 kw-hr. per foot.

TABLE 2

Customary well diameter for surface pipe, main hole, and completion

Conventional practice	*Seminole*	*Lucien*	*Oklahoma City*
Diameter of hole for surface pipe, in.	15½	15½	18
Depth for surface drilling, ft.	40	200	300
Diameter of principal hole, in.	9	11	12¼
Depth for principal drilling, ft.	4200	5000	5500
Diameter of drill pipe, principal drilling, in.	4½	4½ or 6⅝	6⅝
Diameter of hole at completion, in.	9	8⅝	8⅝
Diameter of drill pipe at completion, in.	4½	3 or 4½	4½

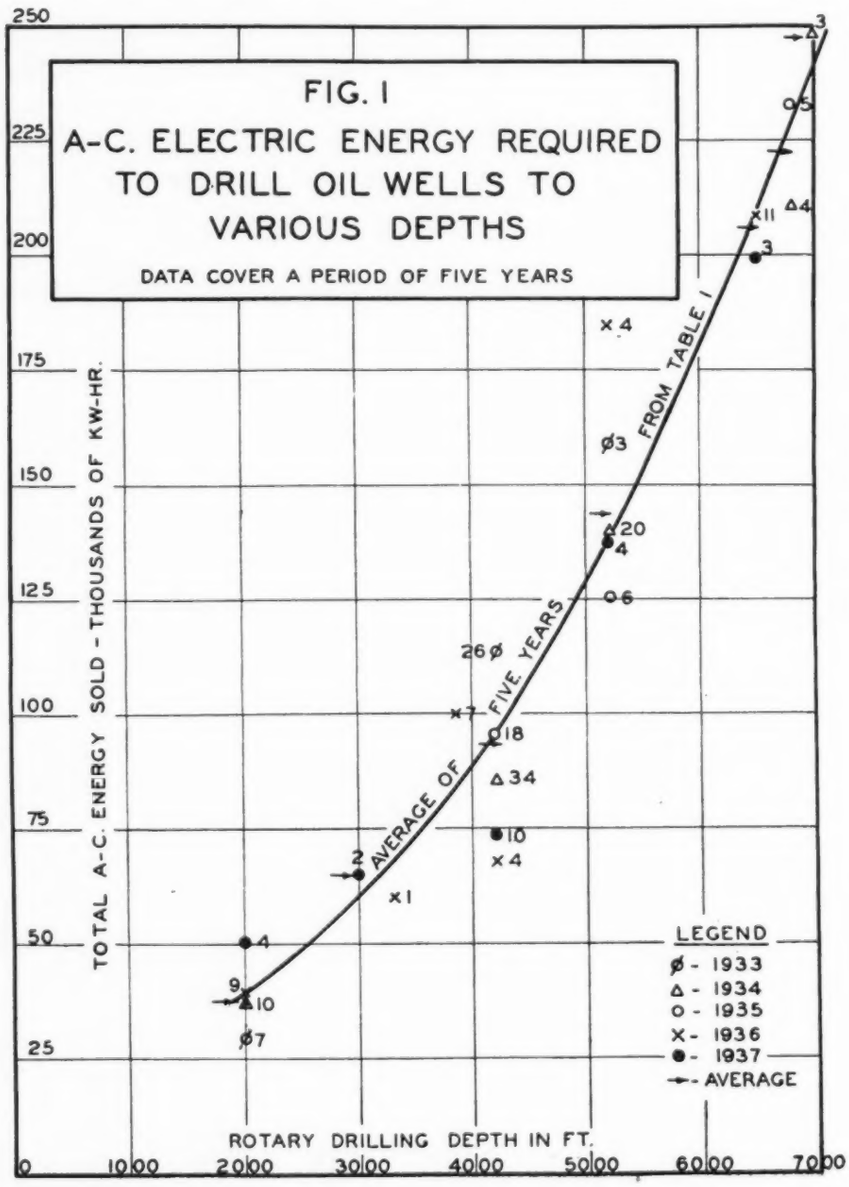


FIG. 1
A-C. ELECTRIC ENERGY REQUIRED TO DRILL OIL WELLS TO VARIOUS DEPTHS
DATA COVER A PERIOD OF FIVE YEARS
TOTAL A-C. ENERGY SOLD - THOUSANDS OF KW-HR.
ROTARY DRILLING DEPTH IN FT.
AVERAGE OF FIVE YEARS
FROM TABLE I
LEGEND
Ø - 1933
Δ - 1934
O - 1935
X - 1936
● - 1937
→ - AVERAGE

The points for the "Lucien" curve are the average for five wells in that field, all drilled with rotary tools to an approximate depth of 5200 feet. The average total energy input was 160,000 kw-hr. per well, or 31 kw-hr. per ft., but drilling on the bottom required slightly more than 80 kw-hr. per foot.

Points on the "Seminole" curve are averages for five wells, all of which were drilled with rotary tools to an approximate depth of 4200 feet. The average power input was 83,000 kw-hr. per well, or about 20 kw-hr. per ft. of depth, but near the bottom the energy input was 48 kw-hr. per foot.

The average total energy consumed in drilling the wells represented by the "Oklahoma City" and "Lucien" curves in Fig. 2 is somewhat higher than the average energy consumed in drilling a larger group of wells, as shown in Fig. 1. The wells represented by the "Oklahoma City" curve were drilled in 1930 and 1931, several years prior to those shown in Fig. 1. Conversely, the average energy used in drilling the wells represented by the "Seminole" curve in Fig. 2 is somewhat less than the average energy consumed for Seminole wells of Fig. 1. It is suggested, therefore, that in attempting to determine the energy required for drilling at various depths the principal use of Fig. 2 is to show the slope of the curve after total energy required has been estimated.

Note the peculiar shape of all the curves in Fig. 2 for the first several hundred feet of drilling, resulting, no doubt, from the use of bits 1¼ to 1½ times the diameter of the bit used for the principal portion of the well in order to permit setting surface pipe. Table 2 gives depths drilled by bits of various sizes and the diameter of drill

pipe customarily used, which correlate with the rate of electric energy consumption in the averages shown in Fig. 2.

The information shown in Table 2 represents conventional drilling practice usually followed in the fields named, but at the time the well logs and electric readings were collected these factors of hole diameter and drilling bit diameter were regarded as non-essential so were discarded.

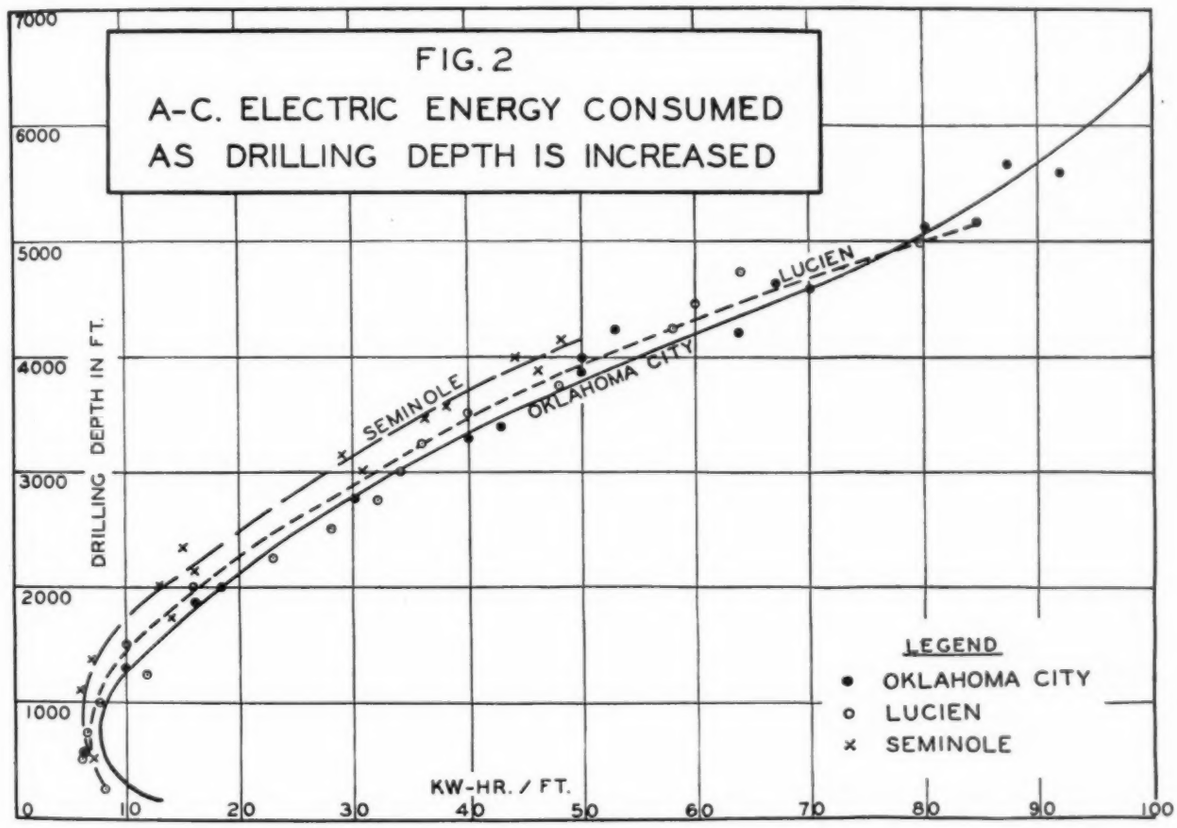
In further reviewing the curves in Fig. 2, note that they indicate, as would be expected, that the "Kilowatt Hours per Foot" required to drill a 9-in. hole (Seminole) is less at every depth than the "Kilowatt Hours per Foot" required to drill an 11-in. hole (Lucien), and that drilling an 11-in. hole (Lucien) requires fewer "Kilowatt Hours per Foot" than a 12¼-in. (Oklahoma City) well. The slight upturn on the "Oklahoma City" curve at a depth of about 5000 ft. can be attributed to the change in hole diameter from 12¼ in. to 8⅝ in. for practical completion of the last 1000 or 1500 feet.

The maximum rate of power consumption has not been discussed nor considered thus far in this survey, nor have any data been shown to indicate drilling time for any of the wells. Most power companies metering loads of this type use either a 15-minute or 30-minute interval in determining the rate at which power is taken from the line. This arrangement eliminates any possibility of measuring the actual instantaneous values. Under this method of metering, for instance using a 30-minute interval, it is possible to demand 300 kw. for 10 minutes, then shut-down completely for 20 minutes, producing a reading only one-third of the maximum, or 100 kilowatts. The energy meter, however, would record the 50 kw-hr. so consumed. Generally speaking, during the actual drilling at depths of 3000 to 4000 ft., the power required to rotate the drill pipe and attached bit is 50 to 75 kw., and 125 to 175 kw. is required by the mud pump, making a total of about 250 kw. actually required for drilling at the greatest depth.

When the drill pipe is being withdrawn to change the bit, or when new lengths of drill pipe are being added, the mud pump is shut-down, and the power required may be only 100 to 150 kilowatts. The ratio of the amount of energy actually consumed to the maximum amount of energy that could be consumed during continuous operation of all equipment is termed "load factor". It rarely exceeds 70 percent for any one day, and averages about 60 percent for the entire period of drilling if shut-downs for cementing or setting casing are taken into account. As the depth increases beyond 4000 ft., the maximum rate of power consumption increases, approaching 300 kw.

FIG. 2

A-C. ELECTRIC ENERGY CONSUMED AS DRILLING DEPTH IS INCREASED



Field	Diameter of hole, in.	Wells studied	Average kw-hr./well
Seminole	9	5	83,000
Lucien	11	5	160,000
Oklahoma City	12¼ 8⅝*	6	290,000

*Last 1500 ft.

TABLE 3

Approximate number of drilling days required, average conditions

Total depth, ft.	*Average energy (Table 1), kw-hr.*	*30-minute average observed kw. at maximum depth*	*Overall average estimated load factor, percent*	*Approximate number of days required for completion of well*
2000	37,882	200	60	13
4200	93,876	250	60	26
5200	143,843	300	60	33
6500	206,371	350	60	43

at a depth of 5000 ft. and 350 kw. at 6000 ft., but the "load factor" remains about 60 percent.

On the basis of this information obtained from experience, it is possible to predict closely the number of days required to drill a well to a given depth under average "fair luck" working conditions.

Table 3 indicates the time required to drill wells to various depths based on average total energy consumed (Table 1) and observation over a long period of time of the rate at which energy is actually taken from the power supply line.

The conclusions reached after analysis of data and information from 195 wells having a cumulative total depth of 160 miles cannot be applied to all wells, no matter where they are drilled, nor can the information be regarded as conclusive proof that the number of days required for completion of wells will be as shown, because there are many factors entering into the actual drilling of a well that can easily affect the ultimate outcome. It is recognized that one drilling crew, operating under given geological conditions and using the same drilling machinery, can operate more economically than another drilling crew doing the same work.

As stated previously, there is a trend toward generation of d-c. power at the well, and it is reasonable to assume that the actual d-c. power required will closely approximate the figures given herein for a-c. power sold. This conclusion is based on the assumption that to obtain closer speed control of a-c. motors a portion of the energy is sacrificed, and performs no useful work but is consumed in resistance grids; whereas, this is not true of d-c. motors. For all practical purposes, however, the losses in the d-c. generator might approach or even equal such a-c. motor grid losses, the actual energy required for operation being almost the same. Furthermore, the fuel required for generation at the well site would be the amount indicated by the fuel economy curve of the engine for slightly more than one-half load or 60 percent rating for the entire estimated period of drilling operations.

The actual fuel consumed in generating d-c. power for drilling wells can be readily computed from the information given. The engines are rarely shut-down during the short periods when no power is actually required for drilling operations, but continue to idle at no load and continue to use a small amount of fuel to overcome mechanical power losses.

Likewise, the cost of electric power (alternating current) can be readily computed as the average maximum demand in kw. is stated in Table 3, along with the average load factor based on average days necessary to complete the well at a given depth. The machinery is not permitted to idle, hence, all power consumed performs useful work.

Early Estimate of Ultimate Recovery of Oil from Louisiana Field Checks Closely with Final Production Figures

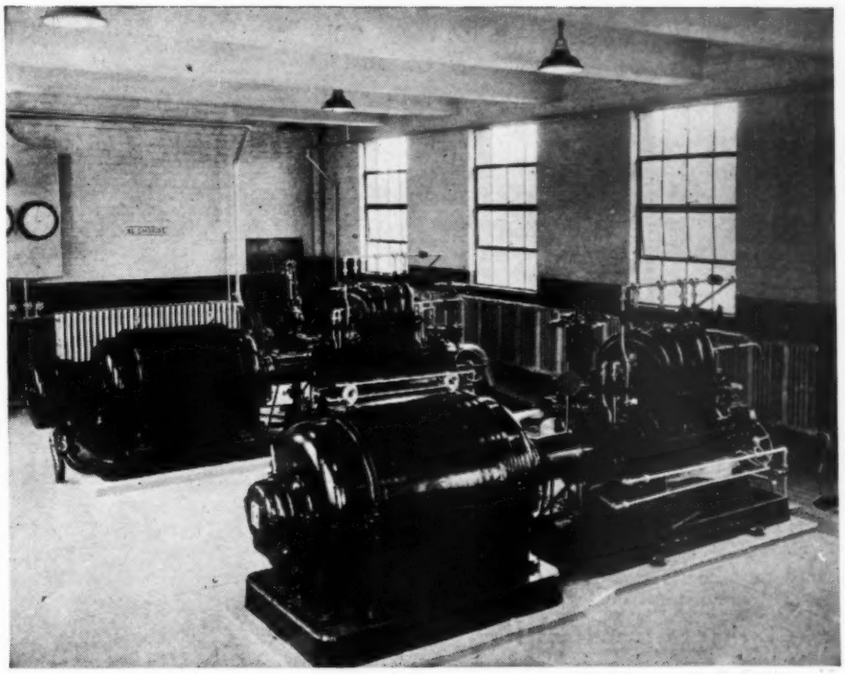
A STRIKING example of the verification of an estimate of the ultimate recovery of oil from a producing zone by actual production figures at or near the end of the producing life of the field has been brought to the attention of the U. S. Bureau of Mines, in connection with the recovery of oil from the Blossom sand in the Cotton Valley field, Webster Parish, Louisiana. The Bureau frequently is asked to supply data of this kind with reference to fields that have been abandoned, but examples are few where the required figures can be given.

In 1931, the Bureau of Mines issued Technical Paper 504, Engineering Report of the Cotton Valley Field. This report is the work of John S. Ross, former petroleum engineer of the Bureau, now on assignment to prepare certain petroleum papers as a part of studies of mineral technology and output per man, a National Research Project of the Works Progress Administration, in coöperation with the Bureau of Mines. Ross studied the Cotton Valley field in detail and reported on its condition as of May, 1930. Using logarithmic production decline curves, Ross estimated "that when the average well in the Blossom sand reached a production of 5 bbl. per day or 450 bbl. per quarter (3 months), the future production would be 3,500,000 bbl., or a total recovery of approximately 14,600,000 bbl. for the field."

According to the American Institute of Mining and Metallurgical Engineers (Transactions, Vol. 126, page 416), the total oil production from the shallow sands of the Cotton Valley field to the end of 1937 was 14,911,015 bbl.—approximately the same quantity as that obtained from Bureau of Mines compilations of production statistics. From the total shallow production, approximately 325,000 bbl. produced from the shallow "Trinity" sand (depleted at the time the report was made and mentioned by Ross in Technical Paper 504), should be deducted in order to obtain comparable figures, or a total of 14,586,000 bbl. of oil from the Blossom sand.

Some additional oil, of course, will be extracted from the Blossom sand in the Cotton Valley field before ultimate depletion, but this quantity will be relatively small as compared with the total cumulative production from that formation. Accordingly, it appears that the estimate by Ross in the Bureau of Mines paper of total recovery of oil from the Blossom sand—made more than 9 years ago, at a time when engineering knowledge regarding the behavior of reservoir fluids was not so advanced as it is today—was within a very small percentage of the actual total recovery from that sand.

Interior of York Station. Motors driving centrifugal pumps



Numerous problems must be successfully solved to maintain efficient operation of an extensive system

Operation and Maintenance of Gasoline Pipe Line System in East

By FRANK L. HADLEY, Vice-President

and

B. K. MORSE, Chief Engineer

Sun Pipe Line Company, Inc., Susquehanna Pipe Line Company, Sun Oil Line Company, and Middlesex Pipe Line Company

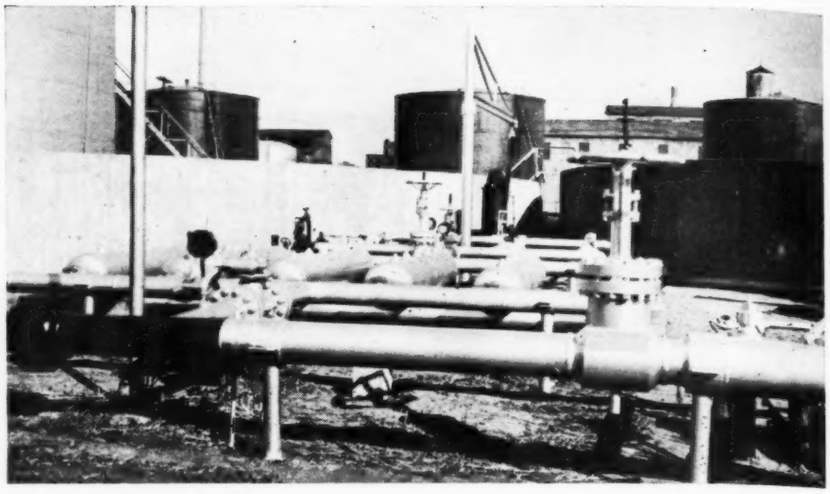
as told to

FRANK H. LOVE

PROBLEMS involved in the operation and maintenance of a gasoline pipe line are typified in the system of the Sun Pipe Line Company's subsidiaries, Sun Pipe Line Company, Inc., Susquehanna Pipe Line Company, The Sun Oil Line Company, and the Middlesex Pipe Line Company. These lines as common carriers serve areas in New Jersey, Pennsylvania, New York, and Ohio, and connect with Lake Ontario, the Erie Canal, and several rivers, affording water connections with other states. The total length of the system is approximately 850 miles. The trunk system is constructed of 8-in. and 6-in. pipe and most laterals are 3-in. pipe. The capacity is 1900 bbl. an hour.

Completion of this system in the summer of 1931 marked the inauguration of the transportation of gasoline by pipe line on an extensive scale in the east. The line originates at Marcus Hook, Pennsylvania, where the Sun Oil Company has a large refinery and where gasoline is received from the Pure Oil Company, and extends to Icedale, Pennsylvania, a distance of about 33 miles, where it branches. One branch extends northwestward to Pittsburgh and Cleveland, a total of 455.05 miles including laterals; the other goes north to Syracuse, a total of 277.75 miles including laterals. This constituted the original line. Since 1931, a 114-mile, 8-in. line has been laid from Marcus Hook to Newark, New Jersey, paralleling the original line to Malvern and continuing to Newark as a single line. The north line, terminating at Syracuse, connects with the Erie Canal and a part of the gasoline is loaded onto barges for transportation east and west. The western line crosses the Allegheny Mountains, passes north of Pittsburgh, and terminates at Cleveland. In the Pittsburgh area connections are made with barge lines operating on the Allegheny, Monongahela, and Ohio rivers. The Sun Oil Company operates its own fleet of barges on these streams, providing economical transportation for the Pittsburgh area and on the Ohio River as far south as Cincinnati. All

Metering equipment at Newark, New Jersey, terminal

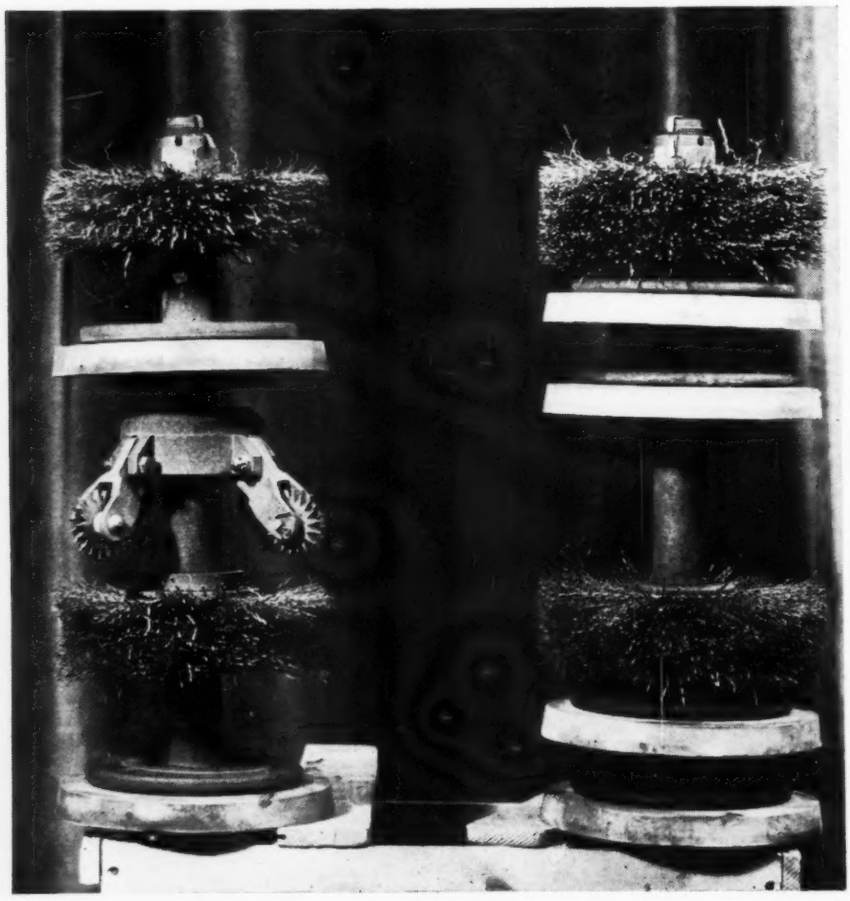


branches of the system pass through densely populated areas and numerous terminals have been provided for distribution of products. These terminals are situated at Malvern, Lancaster, Harrisburg, York, Chambersburg, Cessna, Johnstown, Greensburg, Allegheny, Vanport, Youngstown, Woodland, Mogodore, Akron, Cuyahoga, and Cleveland on the west line; at Reading, Allentown, Tamaqua, Exeter, Willow Point, Binghamton, Cortland, and Syracuse on the north line; and at Willow Grove, Clyde, and Newark on the New Jersey line. Barge-loading facilities are provided at Allegheny, Vanport, Cleveland, Syracuse, and Newark. It is thus seen that this intricate system of transportation involves the use of pipe line, ocean tankers, canal barges, river boats, and lake vessels.

Stations

Because of the varying altitudes of the terrain through which the line passes a problem was presented in the spacing of stations to provide a nearly uniform pumping pressure. Stations were built at Twin Oaks, Icedale, Conestoga, York, Gettysburg, Chambersburg, Fulton, Lovely, Laurel Ridge, Allegheny, Vanport, Beaver, Boardman, Randolph, Tamaqua, Ransom, and Montrose. At Twin Oaks, the originating station, pumping equipment consists of electric motors driving two centrifugal pumps having a capacity of 1600 bbl. an hour each at 850-lb. pressure and one pump having a capacity of 1200 bbl. an hour at 800-lb. pressure. The Icedale station has one 300-hp. and two 400-hp. motors driving two centrifugal pumps rated at 700 bbl. an hour at 900-lb. pressure and one pump having a capacity of 600 bbl. an hour at 800-lb. pressure. The Vanport station is a small standby unit used for pumping from the tank farm at that point. Its equipment consists of a 200-hp. gasoline engine driving a centrifugal pump having a capacity of 350 bbl. an hour at a pressure of 450 pounds.

The new stations, those installed after operation of the line was begun, are at Conestoga, Gettysburg, Fulton, Laurel Ridge, Beaver, Boardman, Randolph, Ransom, and Montrose. Except for Beaver and Boardman these stations have single centrifugal pumps rated at 600 bbl. per hour at 900-lb. pressure, driven by 300-hp. motors. At the Boardman station there are two half-pressure pumps driven by 125-hp. motors. The rest of the stations, the older units, have two centrifugal pumps, one a standby, the capacity of each being 600 bbl. per hour at 900-lb. pressure. At some of the stations 250-hp. motors are employed, at others 300-hp. motors.



Scrapers used in cleaning the line

Operation and Maintenance

On a transportation system as extensive as the one being discussed maximum operating efficiency is essential. This can be attained only by close attention to details. Certain matters are

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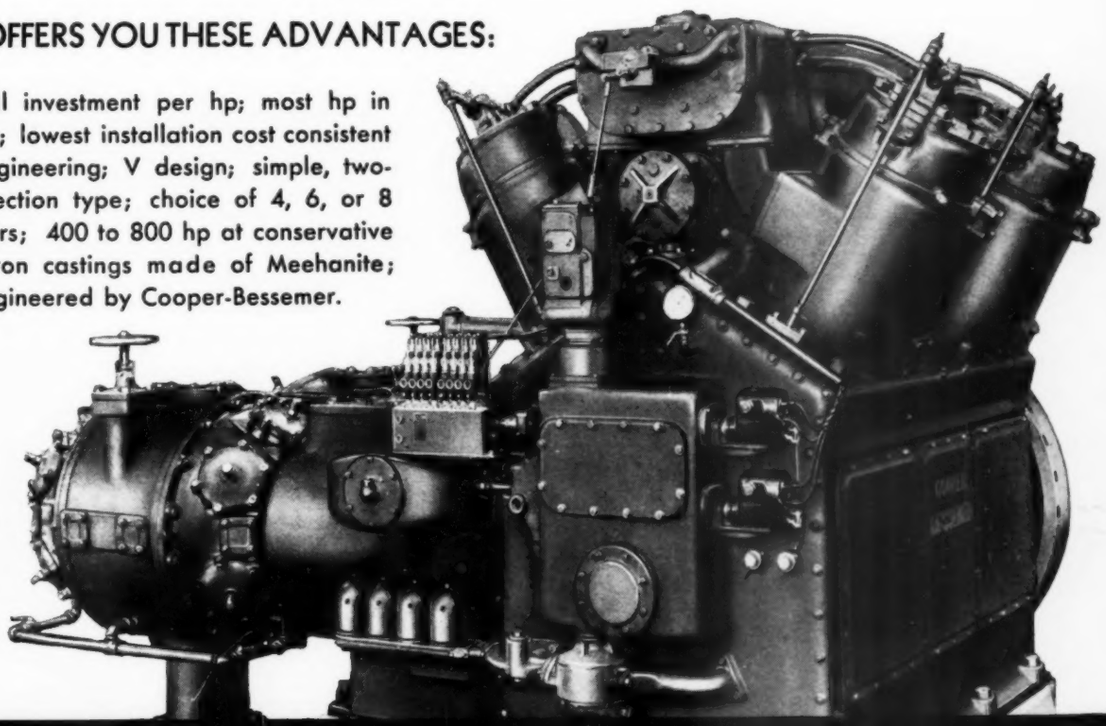

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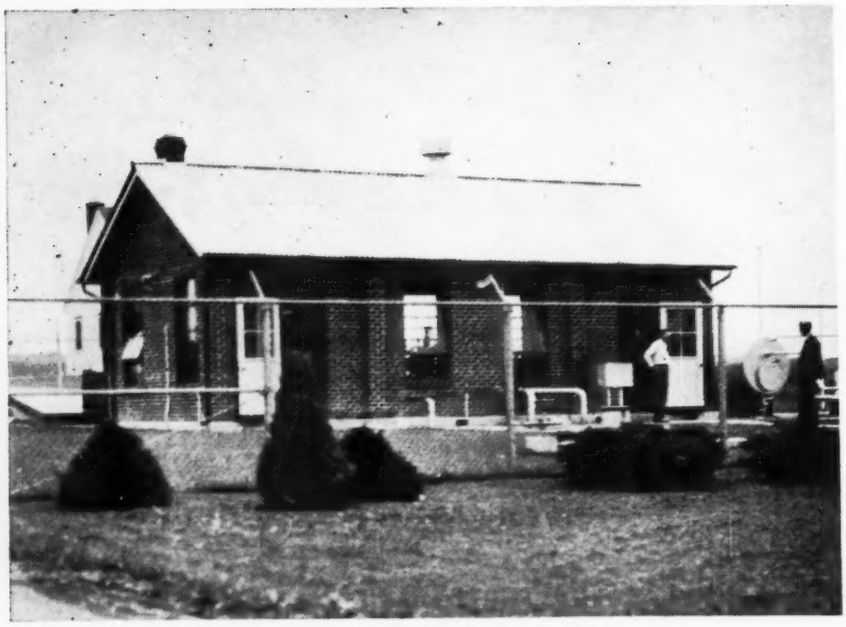

One of the newer stations on the system

routine operating practice so long as they are not neglected but when neglected can develop into serious problems.

The Sun Pipe Line Company gasoline transportation system passes through densely populated areas and one of the problems encountered is the electrolytic action on the pipe of stray currents from street-car systems. Where this condition prevails and wherever practicable the pipe line has been electrically connected to a negative bus at the generating plant of the street-car company, making the line negative to the ground, and this method of protection has been found effective.

Some other conditions also cause corrosion. Much of the line, for example, traverses the Pennsylvania coal country. Here acid tends to cause corrosion. Along the rights-of-way of railroads in Pennsylvania and Ohio the cinders that form the road bed create a similar corrosive condition. A satisfactory method of coping with this problem has been to "box" the pipe, or encase it in a 12-in. square form constructed of cypress or redwood. Into these boxes hot petroleum asphalt is poured and allowed to cool. An accompanying illustration shows a section of pipe after it has been boxed-in and the ditch is ready to be backfilled.

Any great loss in pumping efficiency is avoided by replacing worn parts immediately. Wear on pump parts is ascertained by a constant check of daily records rather than a periodic inspection of equipment. When any particular station shows a loss of pumping efficiency the pumping units are inspected to determine which parts need repairing or replacing. This method has been found preferable, as wear on pump parts varies according to the amount of dirt and other foreign matter that enters the pump. Some of this injurious matter finds its way to the pumps despite all attempts at prevention. At all stations strainers are a part of the regular equipment, some being of the duplex type and some automatic. The use of scrapers through the line is also a part of the operating routine. These scrapers, shown in an accompanying illustration, were designed by members of the Sun Pipe Line Company's staff. As noted, they consist of wire brushes and rubber washers, and they are forced through the line by the fluid pumped. Each station is provided with a trap from which the scraper is removed. The line is cleaned in this manner every two weeks. The scraper shown at the right in the illustration is the type ordinarily used. When another scraper is stuck in the line or if it is thought the scraper may have difficulty getting through because of some other obstruction, wheels are attached to it, as shown at the left in the illustration.

A corrosive area where pipe was boxed

Dispatching, too, is a rather intricate procedure, although perhaps no more so than on other pipe-line systems. All dispatching on the system is done from the Philadelphia headquarters. Numerous grades of gasoline are pumped through the line and it is essential that these do not become mixed. What would seem, on the surface, to be a complicated task is made a routine operating practice by the provision of venturi meters at all stations and bulk plants, teletype communication between Philadelphia and all stations and terminals, and the use of coloring matter to indicate where one product ends and another begins.

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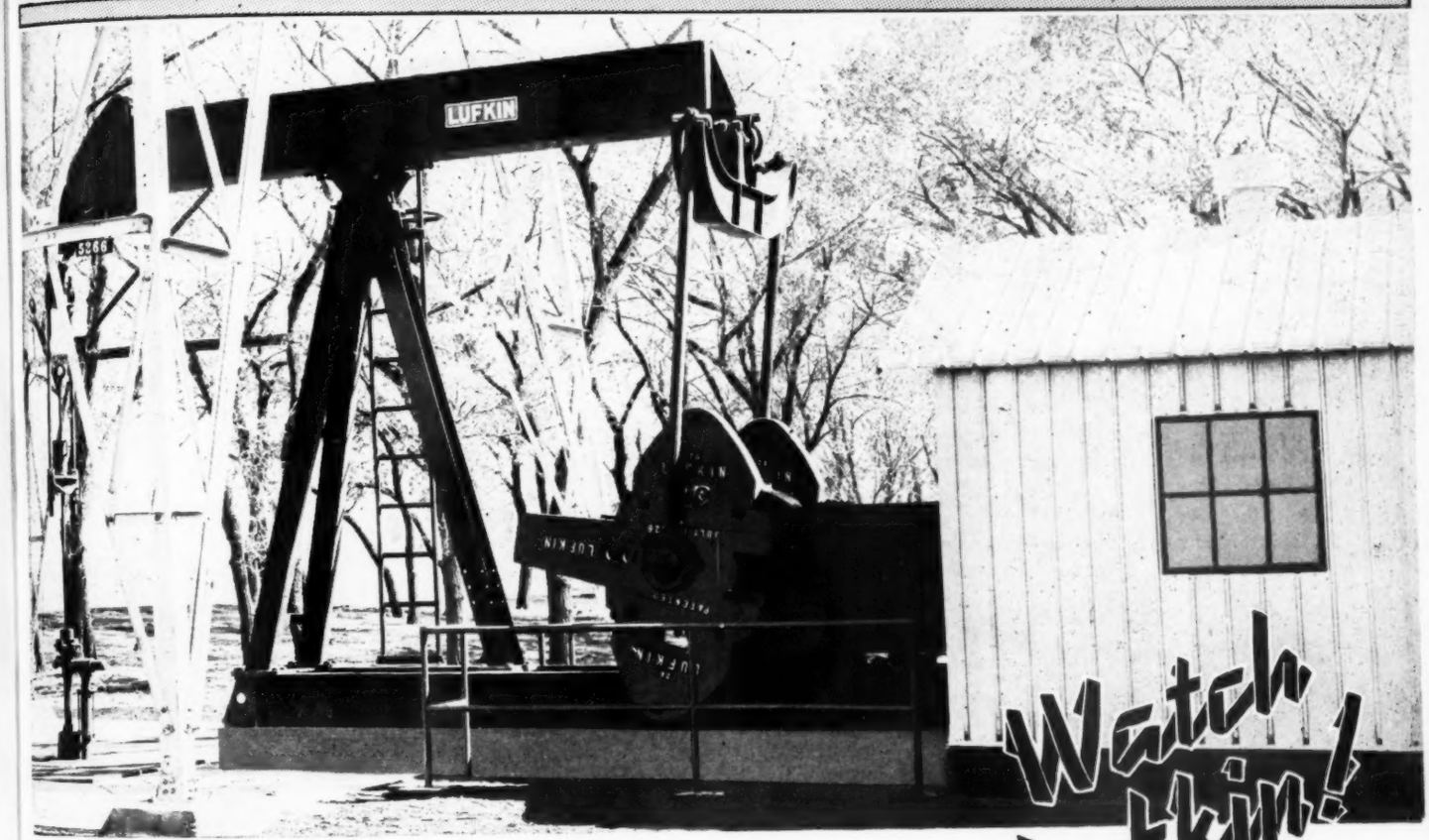

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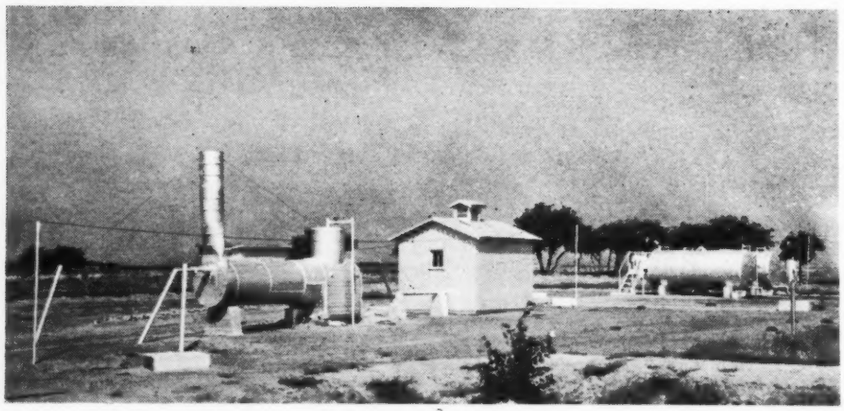


Boiler, regulator house, and gasoline storage tanks for condensate blown from drips

Discarded Boilers Are Used To Heat Water For Warming Gas

The flow line is run through the upper part of the boiler and the gas heated to prevent freezing of regulators

IN the Cement field in Caddo County, Oklahoma, Ohio Oil Company uses discarded oil field boilers to heat water that is used to warm gas as it flows from the wells to the pipe line. The Cement field produces both oil and gas from several zones, and the gas contains fractions that would cause freezing of regulators if the temperature were not raised before the gas flowed through them.

The old boilers are set at convenient points between the producing wells and the pipe line. A torch is used to cut a hole in each end of the shell, one under the smoke box cover above the flues and the other above the crown sheet over the firebox door. A high-pressure 4-in. pipe passes entirely through the shell and is welded tightly to the shell at both openings.

The flow line from the well to the boiler passes through a drip that removes any distillate that forms and collects while the gas is being produced.

A short distance from the boiler the line is raised from the ground through a 45-degree turn and at the height of the pipe in the boiler is leveled by another 45-degree turn, both made by welding. A Dresser coupling is attached to permit contraction and expansion, and to connect the flow line to the pipe passing through the shell of the boiler. At the other end of the boiler similar connections are made but the pipe passes through a regulator house and rests upon concrete piers instead of entering the ground again. By reduction of the pressure, the volume of gas produced is limited to the amount allowed the particular well. The regulator valve will freeze quickly, owing to the cooling effect of the expansion of the gas on the downstream side, unless the gas is heated before it enters the regulator.

Inasmuch as the old boilers are virtually water-tight at low pressure, say three or four pounds, there are no leaks between flues and flue sheets, nor at handhole plates. Water is pumped into the boiler until it half fills the steam dome, which is provided with a gauge glass and fittings. The boiler is fired in the usual manner, gas being used for fuel. The amount of gas required varies, of course, but consumption is small, as the water in the boiler need not be heated to a temperature exceeding a maximum of 200 deg. fahrenheit.

As the 4-in. pipe passing through the boiler is completely immersed in hot water, heat is readily transferred to the gas as it flows to the regulator. A small blaze in the firebox, not much larger than some pilot lights, heats the gas sufficiently to prevent freezing.

For safety to property and employees, each setting is provided with an adequate safety valve, set to pop steam at a pressure of approximately four lb. at most. A 2-in. line connected to the outlet of the safety valve leads to a vent line some distance away, so that if the 4-in. pipe within the boiler should fail, the gas could pass to the air without danger of ignition by the flame in the firebox.

As the pressure of the gas is reduced, the temperature drops rapidly, and a second batch of condensate forms. This is caught in a drip, so that when the gas enters the transmission system it is free from moisture and contains only a small amount of heavy hydrocarbons.

The only material required is a few feet of pipe to raise the line from the ground, and the only other expense is a welder's time while making the connections in the ends of the boiler. The boiler itself, having already been removed from oil field service, is worth only the price it would bring as junk.

This boiler-type heater compares favorably with direct-fired heaters. Safety alone is sufficient justification for using boilers for heating the gas. In direct-fired heaters, and there are several in use in this field, pipe is prone to burn, warp, and drag from couplings, but the greatest damage occurs when the heated section finally ruptures and the stream of gas is ignited. This can not happen in the boiler-type heater, because the line carrying the gas is not subjected to excessive temperature, and, if it should part within the boiler, the gas is carried away where no damage can occur. Thus far no failure has occurred; no regulator has been put out of commission by freezing, and maintenance cost has been negligible.

Pipe Line Construction in Michigan

Discovery of new fields in state has resulted in laying of greatest mileage of pipe line in several years

By NORMAN X. LYON

OIL and gas pipe lines completed, under construction, or projected in Michigan this year total 230 miles, exclusive of field gathering systems and tentative programs. Although this is a comparatively large amount for Michigan in a 9½-month period, most of the lines were short and the diameters small. In 1937 the total length of pipe lines constructed was 197 miles.

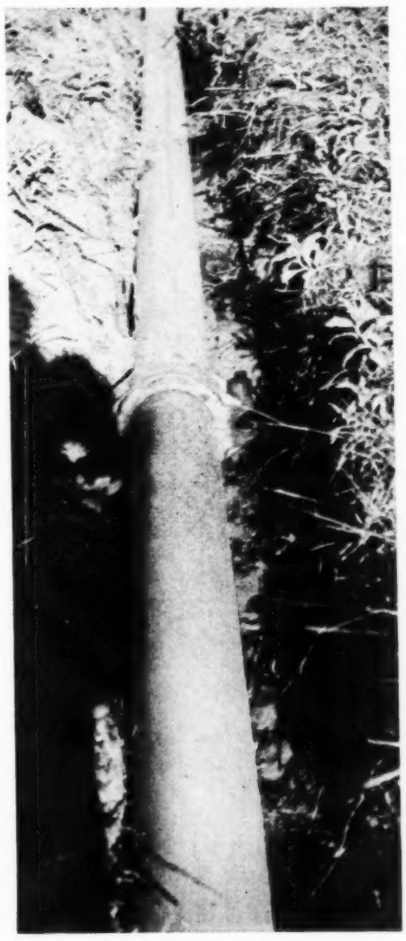
Michigan-Toledo Pipe Line Company, affiliate of Standard Oil Company of Ohio and the Simrall Pipe Line Corporation of Mt. Pleasant, laid approximately 58 miles of new 8-in. line and revamped booster and pump stations to increase delivery capacity into Toledo, Ohio, the southern terminal of the main 8-in. line constructed in 1936 between Toledo and Crystal, Michigan, 28 miles south of Mt. Pleasant. This work is the biggest single construction job completed by an individual company in the state this year.

The 58-mile, 8-in. line was built in two jobs, one completed early in the spring, and the other completed October 20. When Michigan-Toledo constructed the 8-in. line between Toledo, Ohio, and Crystal, Michigan, (132 miles) in 1936, Crystal was made the terminal because at that time the Crystal field was expected to develop into one of the state's largest crude oil reserves. Moreover, the 6-in. line laid a year earlier by Simrall Pipe Line Corporation to transport oil from the Crystal field to Mt. Pleasant and Alma refineries was tied into the 8-in. and proved adequate for several months. Production from the Crystal field declined rapidly, however, and contracts were made with the Pure Transportation Company in 1937 to transport oil from Pure's Porter-Yost and Sherman fields to Pure Oil Company's Toledo refinery via the 8-in. line. Previously most of this oil was shipped by lake tankers from the deep-water terminal on Saginaw Bay to Toledo.

Early in 1937 the Buckeye field, Gladwin County, was opened, and Michigan-Toledo constructed a 35-mile, 6-in. line from Mt. Pleasant station to the field. Several other fields were developed, and early this year officials of the company decided to loop the 6-in. line between Crystal and Mt. Pleasant with an 8-in. line, forming an 8-in. trunk line into the Toledo terminal and reducing the working pressure necessary to maintain volume at the Crystal station.

The 28-mile, 8-in. line was constructed in March by the Berea Construction Company. It is 8⅝-in. O.D., 24.69-lb. seamless pipe 0.277 in. in thickness. All joints are electric-welded. The country between the two stations is almost flat, and use of the right-of-way of the old 6-in. line reduced the necessary preliminary work to a minimum. Only one river crossing was made although road crossings totaled 29.

Construction was completed October 20 on Michigan-Toledo's new 30-mile, 8-in. pipe line between Mt. Pleasant and the Van Horn pool, Clare County, discovered in July, 1938. At Mt. Pleasant the line connects with the 8-in. line built in the spring, providing a trunk line route for oil from the new pool to the Toledo area.



A pipe line in Allegan County, the joints made with special couplings

Berea Construction Company also laid the Mt. Pleasant-Clare line. The line is 8⅝-in. O.D., 24.69-lb. electric weld pipe 0.277 in. thick, and is electric welded the entire route. This is one of the first long pipe lines constructed in Michigan in the summer. The contractors avoided any trouble caused by frozen ground, mud, rain, and snow, and completed the job in about one month's construction time. The terrain at the south end of the right-of-way is fairly flat and open but farther north toward the field it is hilly, necessitating bends of 15 to 75 degrees at intervals of 100 to 300 feet. About 18 miles of right-of-way at the north end had to be "swamped-out" before the builders could install their equipment.

Two 75-hp. engines driving 4½-in. by 10-in. pumps will be placed in the Clare pump station. The company expects to pump 7000 to 10,000 bbl. of oil per day from the field.

The Mt. Pleasant station now serves as the central station of the system, receiving oil from three main fields, Clare-Van Horn, Buckeye, and Edenville-Greendale field stations.

The two 285-hp., 5-cylinder Diesel engines in the Mt. Pleasant station are connected through speed increasers to 6-stage centrifugal pumps capable of delivering at normal operating conditions approximately 1200 bbl. of oil per hour against 750-lb. pressure into the 8-in. line, the engines operating at 450 r.p.m. and the pumps at 3500 revolutions per minute.

An auxiliary 75-hp. engine and 5-in. by 10-in. pump in the Mt. Pleasant station are used primarily to pump oil through the old 6-in. line into storage at Crystal. Oil enters the Mt. Pleasant station through a 4-in. line from the Sherman field and is segregated because its characteristics differ from those of the other oils. The Sherman oil is stored at the Crystal station and then "slugged through" the 8-in. line to prevent mixing.

In the Crystal station two 240-hp., 4-cycle natural gas engines are direct-connected to two 6-in. by 18-in. duplex reciprocating pumps.

In the East Lansing station a 375-hp. 5-cylinder Diesel drives a 6-in. by 18-in. triplex reciprocating pump. The station also has a 75-hp. Diesel and 4-in. by 10-in. standby unit. The same type power and pump are operated in the Chelsea station.

The Mt. Pleasant, Crystal, East Lansing, and Chelsea stations are spaced about 30 miles apart on the 150-mile span between Mt. Pleasant and Toledo. The system is designed to have a normal capacity of 25,000 bbl. per day but can carry about 30,000 bbl. without additional boosters.

Storage facilities include 20,000 bbl. at Mt. Pleasant, 75,000 at Crystal, 5000 at East Lansing, and 10,000 at Chelsea.

The principal field pump stations are those in the new Clare-Van Horn pool, Buckeye, and Greendale. The Buckeye station, 35 miles northeast of the Mt. Pleasant station, includes three 75-hp. engines direct-connected to 4½-in. by 10-in. reciprocating pumps. In the Greendale station two 165-hp. Diesels drive 4-stage centrifugal pumps. As a result of a purchase last spring Michigan-Toledo actually has two 6-in. lines from the Buckeye field to Mt. Pleasant. One line, built by Michigan-Toledo in 1937, goes direct cross-country into Buckeye, and transports most of the Buckeye crude purchased by Simrall Pipe Line Corporation, an affiliate. The other, between the Buckeye field and the Greendale station, due south, was purchased this spring from the Pure Transportation Company. It was constructed in April, 1937.

Michigan-Toledo constructed a 6-mile, 6-in. line from the Edenville pool, opened in February this year, westward to the main 6-in. line. Michigan-Toledo previously had extended a 6-in. welded line 12 miles eastward from the Mt. Pleasant station to Pure's Greendale tank farm, which now is also connected to the Buckeye-Edenville system. Older lines from the Greendale, Porter, and Jasper fields, operated both by Simrall and Pure, connect at the Greendale station.

Michigan-Toledo has 85,000-bbl. storage capacity at the Greendale station.

Also completed early this spring was Bay Pipe Line Company's 33.4-mile, 6-in. welded line between the Buckeye-Bentley field and the Bay City refinery of Bay Refining Company, and a deep-water terminal on Saginaw Bay.

The Bay line was laid by the Rich Construction Company of Bradford, Pennsylvania. It is of 6-in. electric weld pipe and was built during the severe spring of the year when alternately frozen and thawing ground at times threatened to "bog" the entire construction gang. The line is designed for pumping 10,000 bbl. per day at 461-lb. working pressure. Two 50-hp. gas-oil convertible engines in the field terminal station are belt-connected to 5-in. by 10-in. reciprocating pumps.

Additional pipe line construction in Central Michigan this year probably will depend on development in the new Clare pool and possible new discoveries.

Continued expansion of the pool may result in additional pipe line work. Pure Oil Company is now moving its own oil through a 2-mile, 4-in. threaded and coupled line from its one well to rail racks at Temple. Simrall Pipe Line Corporation shipped by a 4½-mile temporary 4-in. line from the field to Lake George before completion of the 8-in. line to Mt. Pleasant. McClanahan Pipe Line Company has proposed a 6-in. line from the field to the company's affiliated refinery at St. Louis, Michigan, a distance of about 50 miles. If this program is not followed the company is almost certain to lay a temporary line to Lake George for rail shipment.

In southwestern Michigan discovery of prolific production from shallow lime this year stimulated extensive drilling. Approximately 70 miles of 4-in. line has been constructed to serve scattered pools in Allegan and Van Buren counties.

Uncertainty as to ultimate recovery and productive life of the pools has delayed the construction of pipe lines that might be anticipated to transport flush production of 20,000 to 35,000 bbl. per day for the district. Prior to July crude was moved by truck-tankers almost exclusively to the Muskegon and Grand Rapids refining centers. Opening of additional pools by mid-year justified construction of three pipe line systems. These are operated by the Naph-Sol Refining Company of Muskegon, the Commonwealth Pipe Line Company of Muskegon, and the Tri Lakes Corporation of Cleveland.

Tri Lakes Corporation, a subsidiary of Standard Oil Company of Ohio, purchased the Simrall Pipe Line Corporation's gathering system and main line September 20, about two months after Simrall entered the field. Simrall also is an affiliate of Standard Oil Company of Ohio.

None of the three systems operates what might be termed a "through line." In each system the lines terminate at railroad loading racks, all crude eventually reaching market by tank car.

Naph-Sol Refining Company now has 26 miles of 4-in. line in operation exclusive of gathering lines. The line connects five pools and terminates at Vriesland. Naph-Sol Refining Company also has two miles of 4-in. line from the Van Buren pool to a railroad terminal in Bloomingdale.

All Naph-Sol's lines are threaded and coupled pipe, and were laid by the

Electric welding an 8-in. line between Mt. Pleasant and the Van Horn Pool

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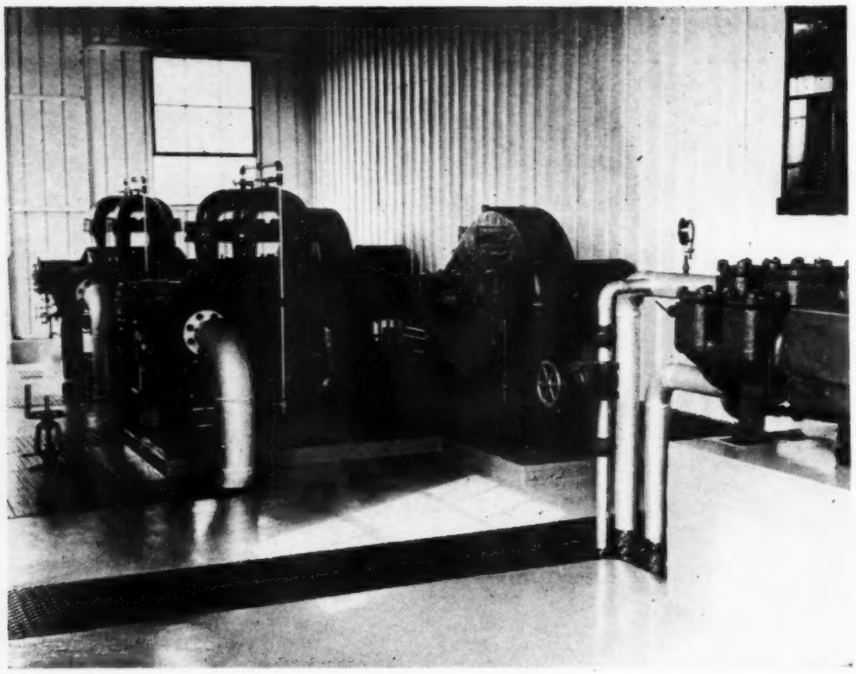

Interior of Michigan-Toledo Pipe Line Company's pumping station at Mt. Pleasant

Shamrock Construction Company of Mt. Pleasant.

Commonwealth Pipe Line Company is operating virtually a parallel system, terminating at Vriesland. This company's lines were laid by its own construction crew. Rolagrip couplings were used on the main 4-in. line, which is 23½ miles long.

The Tri Lakes lines consists of 14 miles of 4-in. seamless Grade A 8.63-lb. pipe in 40-ft. joints, connected by Rolagrip couplings. It was built by Simrall's regular field force.

Pipe line facilities in the fields of southwestern Michigan are inadequate despite the proration, in effect October 15, of 100 bbl. per well in flush districts. Considerable oil is still being moved by trucks.

Owing to market conditions, however, construction of additional pipeline facilities would not be justified. The market demand averages about 7000 bbl. per day, the amount now being transported.

Fearing that townsite drilling, irregular spacing, and unorthodox production methods being practiced in some pools will hasten the decline of the pools, officials of pipe line companies have not indicated any desire to make investments in lines to transport the current flush production.

Naph-Sol and Commonwealth each tentatively plan construction of 4-in. or 6-in. lines from the fields to Muskegon, where most of the oil is now marketed.

Tri-Lakes ships from the Hilliards rail terminal to Chelsea, Michigan, thence via the Michigan-Toledo 8-in. line to Toledo and Chicago markets.

The laying of only short lines to rail sidings, use of threaded and coupled joints, "plow furrow" ditches, etc., indicate that pipe line officials view the current shallow pool boom as temporary.

Pure Transportation Company has virtually ceased competitive purchasing in Michigan except to serve wells of its affiliate, the Pure Oil Company.

A proposal by the Fuel Oil Corporation to establish a deep-water terminal at Point Lookout on Saginaw Bay and to construct 29 miles of 4-in. or 6-in. line from the terminal into the Ogemaw and Arenac fields has been withdrawn. The Arenac Pipe Line Company, however, in which the directors of Fuel Oil Corporation are directors, has bought McClanahan Pipe Line Company's system in the Arenac field, and now ships to Bay Refining Company's deep-water terminal by rail and then by lake tanker to markets, chiefly in the Buffalo district.

Several short gas lines have been completed or are under construction but the biggest proposed gas line, a 300-mile, 16-in., 14-in., and 8-in. loop, probably will not be definitely planned until later. The line was proposed by the Producers Natural Gas Pipe Line Company to connect Michigan fields and to supply several large cities such as Flint, Pontiac, Ann Arbor, and Kalamazoo.

As noted, all types of joints have been employed in laying these lines, including welded, threaded and coupled, and Rolagrip couplings, the last for plain-end pipe. Although welding is generally accepted as being the most satisfactory method of laying long trunk lines, the couplings here mentioned are of interest in their application to certain types of work. In new territory, such as Michigan and Illinois, where the areas are not completely defined, gathering systems are subject to considerable change. The coupled line is being used by some operators for definite purposes because it can be quickly laid and quickly salvaged. Such lines are laid without slack, as each joint takes care of expansion and contraction. On surface lines in territories where climatic conditions are extremely variable this factor is important.

CONSTRUCTION OF PIPE LINES IN MICHIGAN IN 1938

Company	*Terminal*	*Field*	*Cargo*	*Diam., in.*	*Length, miles*
Naph-Sol Ref. Co.	Vriesland	Allegan	Oil	4	26
Naph-Sol Ref. Co.	Bloomingdale	Van Buren	Oil	3	3
Commonwealth	Vriesland	Allegan	Oil	4	23½
Tri Lakes Corp.	Hilliards	Allegan	Oil	4	14
Mich.-Toledo Pipe	Mt. Pleasant	Van Horn	Oil	8	30
Mich.-Toledo Pipe	Lake George	Van Horn	Oil	4	3
Mich.-Toledo Pipe	Inter-Sect.	Edenville	Oil	6	6
Mich.-Toledo Pipe	Crystal	Mt. Pleasant	Oil	8	28
Pure Oil Co.	Temple	Van Horn	Oil	4	2½
Bay Pipe Line Co.	Bay City	Buckeye	Oil	6	34
American-Mich.	Clare	Grant	Gas	4	4
Clareco Gas Co.	Clare	Wise	Gas	3	3½
McBride Coop.	McBride	Home-Day	Gas	3	5½
Consumers Power Co.	Edmore	Home	Gas	4	3½
Northland Gas Co.	Evart	Sheridan	Gas	3	24
Taggart Brothers	Winfield	Morley	Gas	4	8

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CONTINENTAL

Determining the Filtration Characteristics of Drilling Muds

Part 2 (Concluded)

By H. D. LARSEN*

Effect of Pressure

It may be seen that the integrated differential equation shows that if the filter cake were non-compressible, the total filtrate in a given time should vary as the one-half power of the pressure drop across the cake. It is known, however, that the ultimate clay particles are essentially plate-like in shape, two dimensions being possibly 100 times as great as the third. This characteristic undoubtedly plays a large part in the plastering ability of clays as a whole. It must be remembered, however, that many native "clays" are not capable of complete dispersion into the colloidal state, as they contain greater or less quantities of inert, non-clayey material. Moreover, one extraordinary clay has been tested that, although structurally akin to the bentonites, and apparently completely colloidal, loses twice as much water under equal conditions as the very poor clay of Plate 6. The fact that a filter cake of clay consists of platy particles probably more or less in alignment makes it clear why increase of pressure on a cake decreases the permeability thereof.

It has been found that in the clays tested the water-loss may be accounted for as a simple fractional power, less than one-half, of the pressure. Often, and notably in the case of Aquagel, this exponent is zero; i.e., there is no appreciable change in total filtrate with pressure. Some of the native clays, however, that exhibit this independence of pressure are very poor otherwise, either in temperature dependence or total water-loss at any temperature.

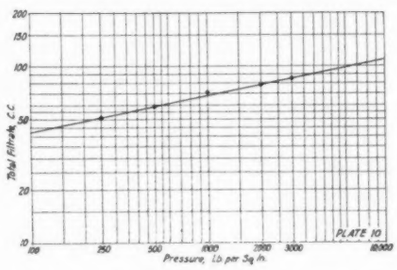
If the total filtrate obeys an equation of the sort $Q = kp^x$ where Q is the water-loss, k is a constant (different from the previous k), p the differential pressure, and x a constant for the particular mud, we may take the logarithms and obtain:

$$\log Q = \log k + x \log p,$$

an equation linear in log Q and log p. Thus, plotting Q against p on log-log paper should give a straight line, if Q is merely an exponential function of pressure.

The data assembled on pressure effect are most nearly complete for Mojave desert mud. Data are shown on Plates 9, 10, and 11 for Mojave desert mud under the following conditions:

Plate	Date of Test	Pressure range, lb./sq. in.	Temp.	Type of Press	Wt. of Mud, lb./cu. ft.
9	Oct. '37	25-4000	Room	(Pneumatic, 25-100) (Carver, 500-4000)	78
10	Mar. '37	250-3000	150°F	Circulating Filter Press	79
11	Mar. '38	100-1000	Room	(Pneumatic, 100) (Carver, 500-1000)	77



Somewhat different functions of filtrate have been plotted in the plates; they are, together with the slope of the line resulting from so plotting them, as follows:

Plate	Function Plotted	Slope
9	Thirty-minute losses in cc., for 3-in. diameter, corrected to filtrate viscosity of 1.00 cpe.	0.176
10	Three-hour losses in cc., for 2-in. diameter, corrected to filtrate viscosity of 1.00 cpe.	0.205
11	Three-hour losses in cc., for 2.25-in. diam. corrected to filtrate viscosity of 1.00 cpe.	0.197

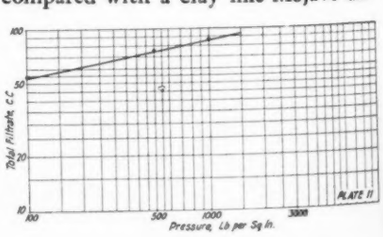
It is clear from the last equation given that no matter in what way the total water-loss is determined, whether one-half or three hours, or by what constant factor the water-losses are multiplied, the slope of log volume versus log pressure will not be affected. Thus, allowing for difference in samples of Mojave desert clay (it will be seen that the tests were made over a period of a year), we may say that Mojave desert clay exhibits a pressure exponent of 0.20. It is of considerable interest that the clay apparently exhibits more or less the same exponent at higher temperature. Mojave desert clay, however, is not appreciably flocculated by temperature. This may or may not be in part explanatory of the results observed.

Plate 12 gives the thirty-minute loss at room temperature for a particular sample of Marginulina shale cored in a well at Seadrift, Texas, and made into a mud of 75½-lb. per cu. ft. density. The pressures range from 25 to 1000 lb. per sq. inch. It may be seen that the points representing total water-loss lie very well on a straight line of slope 0.084.

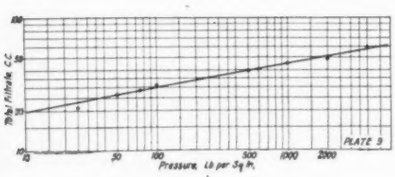
Plate 13 shows a 5 percent Aquagel mud at pressures of 100 to 1000 lb.; a slope of zero is indicated. Three-hour losses at 2¼-in. diameter are plotted.

Plate 14 shows the same Aquagel of Plate 13 badly cut with cement and tested at 150 deg. centigrade. The larger water-loss (three-hour losses, corrected to 68 deg. fahr. and at 2-in. diameter) is apparent, but it is remarkable that no increase of filtrate with pressure is shown.

Plate 15 shows the relative independence of West Texas clay to pressure, compared with a clay like Mojave des-



*Baroid Sales Department, National Pigments and Chemical Division of National Lead Company.



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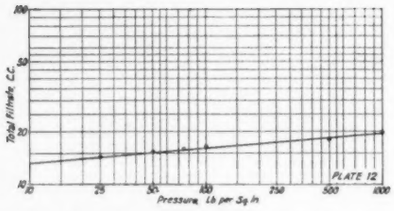


ert clay. It is not clear whether the best straight line should be drawn or not; the experimental error in all filtration tests would probably permit this, in which case the slope would be about 0.04, as shown by the dotted line.

Plate 16 gives the three-hour losses (2¼-in. diameter, 20 deg. cent.) for a drilling mud from a well in the Wilmington, California, field, composed of a clay skimmed from Wilmington slough, Los Angeles County, and a small amount of Aquagel. The exponent of pressure is approximately 0.24 from 100 to 1000 lb., but above 1000 lb. clearly appears to decrease. This unusual behavior is accompanied, it might be remarked, by the fact that the Wilmington slough deposits are of extraordinarily recent geological time compared to the clays of previous plates. This plate should be compared with Plate 13; at 100 lb. per sq. in. the slough mud loses 18.5 cc. as against 17.7 cc. for Aquagel; it might be therefore thought that the wall-building properties were comparable. At 1000 lb. per sq. in., however, the losses are respectively 32 cc. and 18.0 cc.; at this higher pressure the water-loss of the slough mud classifies it as mediocre; twice as much water-loss, it must always be kept in mind, means for the same mud about twice the filter cake thickness, and perhaps twice as much damage to the formation from water incursion.

It is evident that not only should bottom-hole temperature but also bottom-hole differential pressure be duplicated if a truly representative filtration test is to be made on any particular mud. A 500-lb. tester is being perfected so that with a maximum of convenience 100-, 250-, and 500-lb. tests can be made on a mud sample and the results plotted on log-log graph paper, as in Plates 9-16. Thus the behavior of the mud under higher differential pressures may be judged with reasonable certainty.

Cake Thickness and Percent Solids in Mud

When a dry clay is immersed in water and allowed to stand for several days without agitation, it absorbs an amount of water independent of the excess provided for immersion. Such so-called "swelling tests" are well-known, particularly with regard to clays of high water absorptive capacity, such as bentonite. Some results follow:

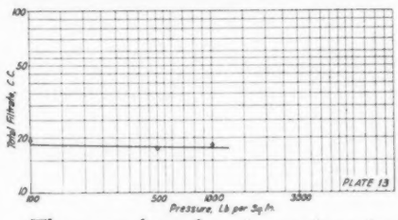
Clay	Percent solids in swollen clay: Room Temp.	200°F.
Aquagel	14.4	16.0
Mojave desert	62.0	57.8
West Texas	40.7	43.7

It is found that filter cake composition is directly related to composition of the swollen clay; the cake contains successively slightly less water as the pressure at which it was deposited increases; at low pressures the cake composition approaches that of the swollen clay. For example, the following results were obtained on three widely different clays:

Differential Pressure, lb./sq. in.	Percent Solids in Cake: Aquagel (4.53%)	Mojave Desert Clay (30.2%)	W. Texas Clay (24.2%)
0	14.4	62.0	40.7
100	15.0	64.8	45.1
500	16.1	68.0	47.2
1000	16.7	69.4	53.0
2000	.....	.....	52.8
3000	.....	.....	53.1

Comparative independence of cake composition with regard to percent solids in the mud is shown by the following results, at 100 lb. per sq. inch:

Mud	Percent solids in cake
3.17% Aquagel	16.5
4.53% Aquagel	15.0
6.80% Aquagel	15.2
23.4% Mojave desert clay	64.5
30.2% Mojave desert clay	64.8
39.6% Mojave desert clay	65.4



These results taken in conjunction with the swelling data at two different temperatures give validity to the statement that a change in the product $Q.\sqrt{\eta}$, i.e., a change in the temperature-corrected water-loss at two different temperatures, betrays a change in the colloidal state of the clay itself. At least the change is probably not due merely to a change in the degree of swelling of the clay at different temperatures, giving a different R or ratio of filtrate to cake. Data have not been obtained for the composition of hot-filtered cakes.

In the data just given, the time of each test was the same, namely, two hours. It is found, however, that the composition of cakes deposited for different times from the same mud is virtually the same. Cakes sometimes appear non-homogeneous, that portion last deposited being somewhat softer. It must be kept in mind in this regard, however, that the composition of the cake as deposited is at the critical swelling composition; a trifle less water results in a much harder mass, whereas a very little more results in a soft mass. Anyone who has mixed concrete will appreciate the effect of addition of water beyond the point where the concrete just becomes plastic.

It is well known that the swelling of clays is greatly inhibited by the presence of electrolytes. Thus it is found that clays in salt water often lose astonishingly much water, and some of this loss must be attributed to a greater R.

Cake thickness, given uniform composition of cake, is seen from the foregoing to be necessarily proportional to the loss of water from the mud, and thus if previous analyses are correct, proportional roughly to the square root of time. Plate 17 shows results of *cake thickness* vs. *time* for five Gulf Coast drilling muds. The second, third, fourth and fifth lines from the bottom have had successive increments of 10/32 in. added to effect a vertical separation on the chart. Each line passes through its own origin. It will be seen that the law just stated is very well followed. The long duration of the runs—twenty-four hours—is noteworthy.

The muds in Plate 17 are as follows, from bottom to top:

1. Well located at Peach Point, Texas.
2. 4% Aquagel weighted to 16 lb. per gal. with Baroid.
3. Well located at Agua Dulce, Texas.
4. Well located at Premont, Texas.
5. Well located at New Iberia, La.

In order to get the three points shown for each mud, three filtration tests were started simultaneously, the

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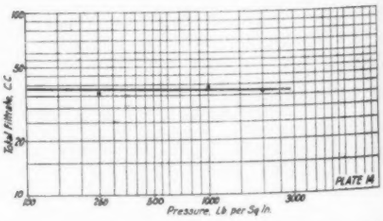

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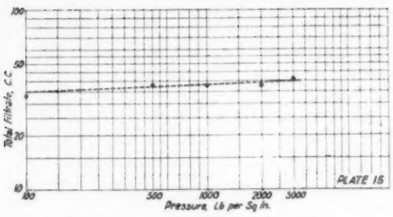

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first interrupted at thirty minutes, the second at three hours, the third at twenty-four hours, and the thicknesses determined at the end of each run. Tests were made at room temperature and 100-lb. per sq. in. pressure.

Having established some of the relatively simple relations governing cake thickness and composition, the closely allied question of percent solids in the mud as affecting filtration may be discussed. We may determine from measurements of percent solids in the mud and in the cake the ratio of filtrate to wet cake weight. Thus if a mud is 20 percent solids and the cake therefrom is 60 percent solids by weight, for each 100 gm. of mud before filtration there will be deposited 33.3 gm. of wet cake containing 20 gm. of dry clay, and there will be expressed 66.7 gm. of water. R as herein used will then be $66.7 \div 33.3 = 2.00$. Such a calculation checks very well with actual measurements of water-loss and cake weight and does not suffer from the disadvantage of the last procedure in that it is difficult to obtain all the deposited cake for weighing purposes.

There are presented below data illustrative of these considerations as follows:

Mud	% Solids in mud	Three hr. loss	% Solids in cake	R	$\sqrt{R}$	Loss $\div \sqrt{R}$
Aquagel	3.17	42.1	16.5	3.87	1.97	21.4
Aquagel	4.53	35.5	15.0	2.43	1.56	22.7
Aquagel	6.80	24.3	15.2	1.28	1.14	21.4
Mojave desert clay	23.4	107.4	64.5	1.77	1.33	80.6
Mojave desert clay	30.2	103.1	64.8	1.15	1.17	88.0
Mojave desert clay	39.6	97.4	65.4	0.64	0.80	121.4

These tests were made for three hours at 100 lb., pneumatic tester at room temperature. In computing R the average percent solids for each mud was used. Now reference to the integrated equation will show that water-loss may be expected, at least as a first approximation, to vary as the square root of R. Comparison of the first three figures in the last column above shows that this rule is obeyed remarkably well by Aquagel; but the gross failure of the relation to hold true of Mojave desert clay is evident from the last three figures in the last column above. Rather the one-tenth power of R is found to fit the data much more closely. These are the only data for different concentrations of the same mud so far at hand.

Effect of Filter Material

It has been tacitly assumed so far that the type of filter bed material, whether compressed sand, natural sandstone, or filter paper, had no great effect upon the result obtained. Actually this is for all practical purposes true. For example, Plates 18 and 19 give respectively data for 6 percent Aquagel and 79½-lb. per cu. ft. Mojave desert muds tested on the pneumatic press at 100 lb. per sq. in. pressure, at 20 deg. cent., and on four different kinds of filter beds. The characteristics of the filter formations are as follows:

Type of Filter Bed	Thickness used, cm.	Permeability, millidarcys	Porosity, percent
1. Sand* from Kettleman Hills core (7140 ft.) compressed at 12,000 lb. per sq. in.	2.5	25	23
2. Sintered alundum disc, coarse, designation RA 98	0.36	560	54
3. Sintered alundum disc, medium, designation RA 225	0.36	440	49
4. Whatman's toughened filter paper, No. 50	0.011	0.36**	

*Screen analysis of sand:

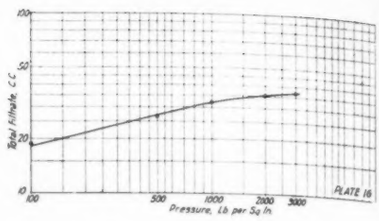
Mesh	Percent Retained	Cumulative Percentage
-14	0	0
14-28	24.8	24.8
28-50	33.7	58.5
50-100	27.1	85.6
100-200	9.1	94.7
200-	5.3	100.0

**This value with water at 100 lb. per sq. in. across paper, assuming dry uncompressed thickness. On same basis, permeability decreased almost linearly with pressure across paper. For example, at 33 lb. per sq. in. it was 1.02 millidarcys, and at 20 lb. per sq. in. it was 1.75 millidarcys.

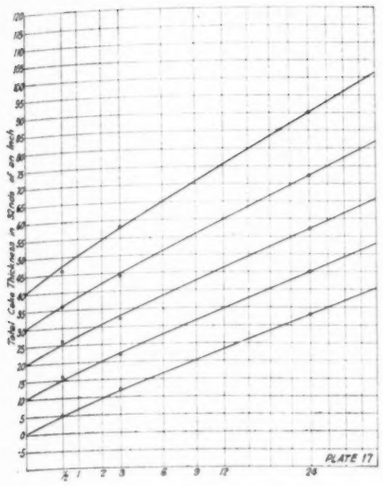
The corrected water-loss and cake thickness for three hours for the two muds are shown below:

Material	Water-loss from Slope of line, cc.	Cake Thickness, 32nd in.
Six percent Aquagel		
Sand	36.9	3
Sintered alundum, RA 98	35.6	3
Filter paper, Whatman's No. 50	34.6	3
Sintered alundum, RA 225	33.8	3
Mojave desert clay, 79 lb. per cu. ft.		
Sand	87.4	12
Sintered alundum, RA 98	86.2	12
Sintered alundum, RA 225	85.1	12
Filter paper, Whatman's No. 50	78.3	12

It may be seen from the plates that on both muds the compressed sand and the two alundum discs give very good straight line approximations when



plotted on the special graph paper. The filter paper has an extraordinarily low permeability, however, as may be seen from the table on this page, and it appears probable that the first "skin" of filter cake deposited on and necessarily to some extent in the surface of the paper has an unduly smaller permeability than portions of the cake subsequently deposited on top of more cake rather than in superficial pores of the filter paper. Thus the rate of filtration is initially inhibited, but as the resistance to further filtration is offered proportionately less by the bottom of the cake and more by the main body of the cake, the filtration rate gradually increases, approaching asymptotically the straight line value of the sand-alundum disc filtration rate. Herein lies the justification for taking the slope of the straight line

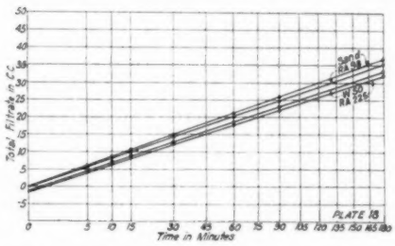


from later readings, and neglecting five- and ten-minute readings when these are not collinear with the others. This indicates, incidentally, another advantage of the special graph paper of Plates 18 and 19 over log-log paper; the initial inhibition of filtration where filter paper is used gives an apparent time exponent of somewhat more than 0.50; this is obviated and a more nearly true picture is obtained by plotting the data as in Plates 18 and 19. Notwithstanding these objections, filter paper is of course used in routine tests because of its extreme ease in manipulation and very low cost.

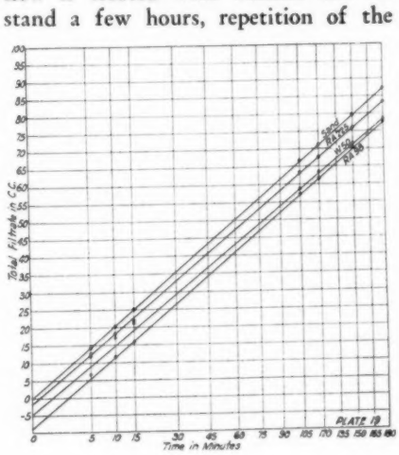
Felt pads have been proposed as filter media but are not satisfactory as the grades of felt commercially available appear to let a great deal of even thick mud through before any cake is deposited. It may be possible to develop a sintered stoneware disc of suitable porosity and permeability that is inexpensive enough to use once and throw away. This is now being given consideration.

Effect of the Colloidal State of the Mud

In order for clays to exhibit their property of plastering and forming a more or less impervious seal, it is evidently necessary for the individual particles to pack somewhat, it may be presumed, like fish scales. In order, however, for this to take place, the particles must be in general deflocculated; that is, each particle is reduced to its smallest particulate subdivision and is free to move independently of the others. The means whereby this becomes possible is one of the primary problems of colloid chemistry, and is fairly well understood. An extended discussion of the subject would be of course out of place here; it suffices to note that the conditions for stability of a clay particle are disturbed in a two-fold manner by the presence of electrolytes: first, the double-layer potential that interposes a potential energy barrier to the coalescence of two particles is lessened by the adsorption of cations, particularly those of higher valence, and most commonly in actual well conditions of calcium ions from ground waters and cementing operations; and second there occurs the "salting-out" effect of competitive hydration of the ions of the electrolyte, thus reducing the possibilities of hydration for the clay particle. This is to be sure an oversimplification; but it is to be noted that both calcium ions, even in relatively small concentrations, and salt, as sodium chloride, etc., serve



to bring about a state of the clay suspension known as flocculation, wherein the ultimate particles of clay no longer move independently but are agglomerated, presumably at points of flocculation on the particle, so that a more or less open network of particles results. Hydration is lessened and the phenomenon of syneresis occurs, wherein the flocculated gel shrinks and free water appears. Under proper experimental conditions, a given clay mud can be squeezed lightly in a cloth bag in the manner in which fruit juices are expressed in jelly-making and unaltered mud will squeeze through. If the mud now is treated with cement and let stand a few hours, repetition of the squeezing, if carefully done, will produce clear water first, and only later will the flocculated mud appear.



Again, an ordinary mud may be mixed with brine and much the same phenomenon will occur. A simple field test for flocculation, which is useful where agitation or very high gel-strength obscures the effect of syneresis, is to dilute a small amount of the mud with distilled water, say 1 :20 by volume, shake in a stoppered cylinder very thoroughly, and let stand for several hours, preferably overnight. A deflocculated mud will remain "muddy" all the way to the top of the column for a day or more, whereas a flocculated mud will settle to the bottom, leaving the remainder clear, in a very few hours.

The property of flocculated muds, at least those flocculated by calcium ions (insufficient work has been done on other types of flocculation to warrant any general statements about them at present) that is of greatest interest here is their inability to form an impervious seal; the water-loss of a given mud under given conditions may be multiplied many times upon flocculation by, for example, drilled-out set Portland cement. This is a not unexpected result if one bears in mind the picture just presented of a flocculated clay as a network.

As examples, there are given the viscosity in Stormer centipoises and the water-loss in cubic centimeters for a one-hour, 100-lb. test on two muds:

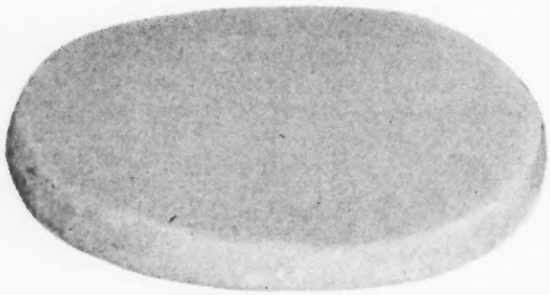
Mud	Cement added, lb./bbl.	Viscosity	Water-loss
Mojave desert-Aquagel	0	6	65.8
Mojave desert-Aquagel	3	30	142.1
Aquagel (6 percent)	0	26	17.8
Aquagel (6 percent)	2	....	31.1

It may be remarked that there are chemical methods available for overcoming the effects of cement, the original water-loss or even better being restored. Slight cement-cutting and ordinary flocculation of native clays, mud made in the normal course of operations by hydration of drilled-out shale, etc., may be effectively treated with a chemical mud thinner such as Stabilite. Viscosity reduction is accompanied by a corresponding decrease in water-loss and cake thickness. The treatment of badly cement-cut muds, formed wherever any considerable quantity of cement is drilled-out, will not be discussed here.

Field Applications

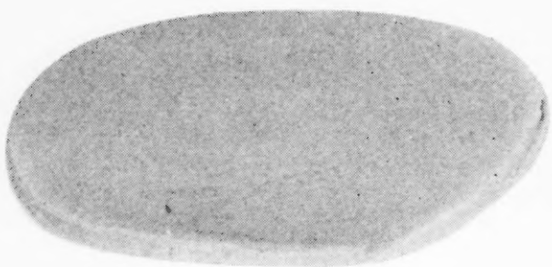
During actual drilling, cake thickness is reduced and perhaps kept more or less constant by hydraulicking from the moving mud, by recurrent contact

Actual size cakes from Aquagel-water and poor native clay muds tested on Baroid low-pressure wall-building tester at 100 lb. per sq. in., for three hours, at 80 deg. fahr. and 200 deg. fahrenheit.



Aquagel—200 deg. fahr.

Native clay—200 deg. fahr.



Aquagel—80 deg. fahr.

Native clay—80 deg. fahr.

of the drill pipe and the walls of the hole, by scraping by the drill pipe, and so on. These factors do not operate while the drilling is suspended for any reason. Another difference between laboratory and bottom-hole conditions is that the permeability of the formations varies from virtually zero to exceedingly high values; no filter cake will be formed when drilling through, for example, a dike of granite, as there is no place for the filtrate to go. Despite these differences, however, a mud that behaves poorly in laboratory tests is bound to behave poorly somewhere during the course of the average drilling operation. For example, even though hydraulicking and scraping keep the filter cake (at 150 deg. fahr. and 1000 lb. per sq. in. differential pressure) to a thickness of ¼ in., let us say, it may be seen from Plate 1 that this corresponds to the thickness of a three-hour Aquagel cake, which loses under these conditions 6.8 cc. water per hour (2-in. diameter). From Plate 3 and the accompanying data it may be calculated in an obvious manner that a ¼-inch cake corresponds to a West Texas clay cake only about 35 minutes old, at which point the water-loss may be seen from Plate 3 to be about 30 cc. per hour (2-in. diameter). This means, then, that even though cake thickness be kept to ¼ in., the West Texas mud loses *nearly five times as much* water to the formation in a given time as the Aquagel mud, assuming, of course, a reasonably porous formation. The result of this greater loss will generally be a much greater tendency to cave, and, if a producing formation, greater damage thereto by water incursion.

Again, assume that drilling conditions are unusually easy, that the formations have no tendency to cave, and that only a very slight porosity exists all the way to the oil sands, so that almost any sort of mud may be used with success. Eventually the productive formation will be drilled and a liner set; even under the best working conditions the face of the oil sand will be exposed for several hours before swabbing can be begun. During this time, if a poor mud is used, and a reasonable differential pressure exists, a thick and generally hard filter cake will form on the face of the oil sand, which will have to be broken or somehow forced through the slots of the liner before production can begin. If the poor mud is used the permeability of the formation will be impaired by the greater water-loss.

Thus it is seen that the results of filtration tests do not lack appositeness to actual drilling; enough is now known about the methods of testing drilling muds that it can be stated with considerable certainty that a mud that performs badly in the laboratory is most likely to perform badly in the hole and eventually cause the operator much more financial loss than use and proper conditioning of the right mud would have in the first instance. It should also be kept in mind that not all the harmful effects of poor muds are apparent to the drilling crew; more and more it is realized that the evils of poor mud live long after the mud has been discarded and production begun; lowered production, permanent sealing of narrow strata within the producing zone, casing corroded by ground waters

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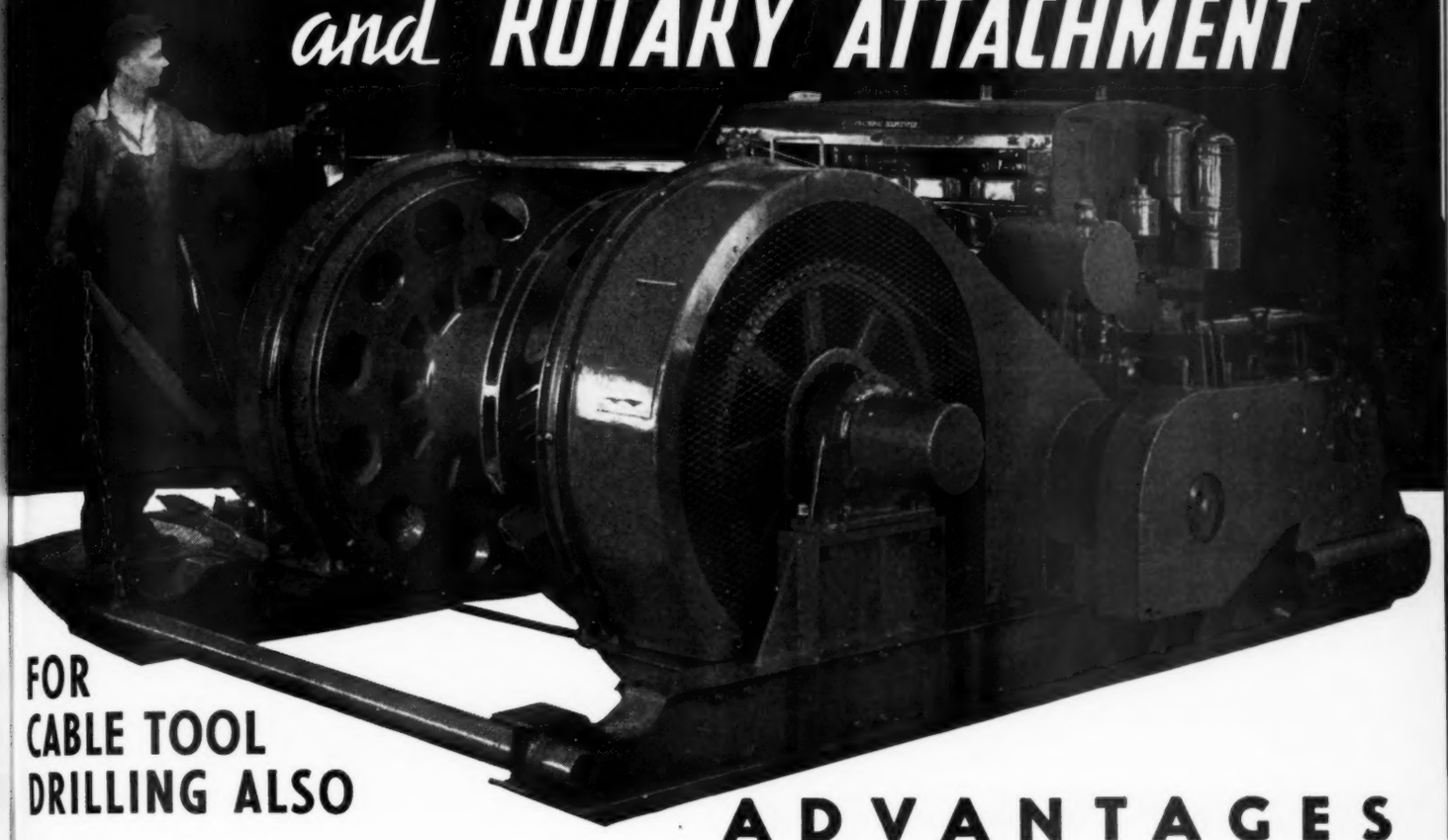

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ADVANTAGES

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- Centralized Controls provide easy operation from the driller's position.
- Large Brakes and Drum Assembly give considerable advantage over conventional equipment.
- Easy Portability: Weight 11,000 lbs. without engine.
- Power: Gas or Diesel up to 150 H.P. with Maximum Torque of 550 ft. lbs.

SPOOLING CAPACITY

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LOWER DRUM		UPPER DRUM	
Size of Line	Length in Feet	Size of Line	Length in Feet
¾"	10,000	¾"	6,300
⅞"	7,300	⅞"	4,500
1 "	5,500	1 "	3,400

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or even by corrosive mud years after the well is completed, water leaks of various kinds—all these are found in the long shadow cast by poor muds.

Summary

1. *Water-loss* is proportional to the one-half power of *time*, and is best plotted against this power of time to give the best straight line.
2. The *straight line* plotted as in (1) gives, if early readings are neglected, a good approximation of the *actual water-loss* independent of the nature of the filter-bed material.
3. *Water-loss* is inversely proportional to the one-half power of the *filtrate viscosity*, which may be calculated from the temperature if other conditions remain unaltered. As a corollary,
4. *Water-loss* multiplied by the square root of *filtrate viscosity* gives an index to the water-loss independent of filtrate viscosity, and thus enables one to judge the effect of temperature on the mud itself.
5. *Water-loss* is generally an exponential power of the *pressure*, and thus may be plotted against pressure on log-log paper to give a straight line.
6. *Cake thickness* is proportional to *water-loss*, other things being equal.
7. *Cake composition* is largely independent of *time*.
8. *Cake composition* varies only slightly with *pressure*, and approximates at low pressures the composition of the naturally water-soaked clay.
9. *Cake thickness* is proportional, from (1) and (7), to the square root of *time*.
10. *Water-loss* appears to be an exponential function of the *ratio of filtrate to cake* (whether volumes or weights), and in the ideal case the exponent would appear to be one-half.
11. *Cake composition* does not vary for a given mud in various dilutions with water, that is, at different *percent solids content of the mud*.
12. *Water-loss* is largely independent of the *nature of the filter bed material*, within reason.
13. *Water-loss* is independent of *circulation* past the face of the core, as long as this circulation is slow enough not to hydraulic-off the cake.
14. *Water-loss* is increased by *calcium ion flocculation* of the mud, and from (6),
15. *Cake thickness* is increased by such *flocculation* also.

Don't Overload High-Friction Belts

By W. F. SCHAPHORST

IT IS well to keep belts pliable at all times so that they will grip the pulleys easily and run properly without slipping. Proper treatment of a belt will do this. Slack, easy-running belts are always desirable because of the lower initial tension and reduced bearing pressure.

There is one outstanding objection, however, to the slack belt, and that is, users are likely to overload such belts. Most users of belts seem to think that when a belt is running slack it is not pulling full load. It doesn't look just right for one side almost to touch the other. We have become so accustomed to tight belts and high initial tensions that we cannot readily rid ourselves of the idea. When the time comes to increase capacity or load, the operator of the slack belt says, "Well, this belt handled the old load so easily that I am sure it can handle a great deal more, therefore we won't buy a new belt."

Such reasoning is all wrong. A leather belt cannot stand more than a definite stress day in and day out and year in and year out. Excessive stress will quickly stretch the belt and ruin it causing it to break prematurely. Treating a belt does not make it stronger. It simply makes the belt waterproof, more pliable, and longer-lived, and increases its coefficient of friction. The same formulas that are used when computing loads for untreated or ordinary belts should be used for treated high-friction belts. The belt thus loaded will be amply strong and generally a truly high-friction belt can be run slack. A high-grade belt of that type can be run "easy" at least.

Here is the rule of thumb that is most commonly used for 1-ply belts, because it is usually well within the limits of safety:

"A single-ply belt, one in. wide, running at the speed of 800 ft. per min., will transmit one horsepower."

For 2-ply belts the rule of thumb is:

"A 2-ply belt, one in. wide, running at a speed of 500 ft. per min., will transmit one horsepower."

Method for Separation of Wax From Petroleum

A basic method for analytical separation of wax from oil in crude petroleum and petroleum distillates has been developed by chemists of the U. S. Bureau of Mines. The need for an accurate analytical method for the separation of wax from oil by means of organic solvents arose in connection with recent studies of crude petroleum and its wax distillates by the Bureau of Mines in coöperation with the State of Oklahoma. Two selective solvents are employed with control of the temperature at which the separation is made, solvent-solute ratio, and relative proportion of the two components of the solvent. A report recently published giving the results of the study presents data to illustrate the application of the method and describes the simple laboratory apparatus and details of mechanical manipulation that must be followed rigidly in making the separation.

Because the solubilities and intersolubilities of the wax, oil, and solvent in an intimate mixture vary at different temperatures and concentrations, no definite proportions of solvent to oil were found generally applicable to all oils used to obtain the desired extractions. Some preliminary experimentation always was necessary to determine the quantity of solvent and the extraction needed to separate all the wax or a particular group of waxes.

Fractional separation of wax into cuts having distinctly different melting points was accomplished.

Other solvents may be employed that have properties similar to acetone and methylene chloride, the solvents used in this study.

Bureau of Mines Technical Paper 583, "A Study of a Solvent Analytical Separation of Waxes from Petroleum and Its Lubricating Fractions," by J. W. Horne and W. C. Holliman, is sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., for ten cents.

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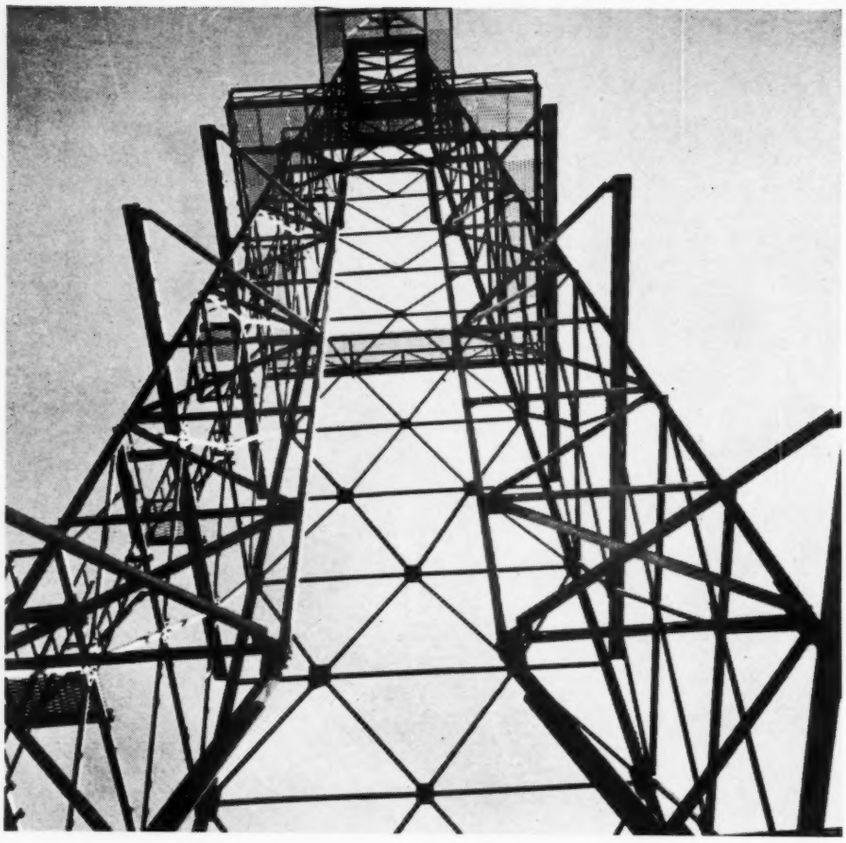

Fig. 1. This new type derrick has a window that extends to about 73 ft. above the derrick floor

By

WALLACE A. SAWDON

Petroleum Engineer, Los Angeles, California

Drilling and Casing Deep Wells In California

Size and strength of equipment already available are adequate to run or pull long, heavy strings of drill pipe or casing

THE completion of deep producing wells in the San Joaquin Valley of California at depths of 11,000 and 13,000 ft. has proved that casing programs can be designed to meet any conditions encountered under present drilling limitations. The usefulness of float shoes and collars in landing and cementing the casing at these great depths has been demonstrated. Metallurgy has, of course, provided the steel alloys requisite for the manufacture of the long strings of casing now being used, but improved joint design has facilitated insertion of long strings of pipe into the hole safely and more rapidly.

Derricks of present design are well able to support the weight of the long strings of pipe, and equipment for floating has assisted in relieving the strains that are imposed on the derrick, lines, hook, blocks, etc. The heavy rig equipment now being widely used has proved capable of running and cementing the 13,000-ft. casing strings after drilling to a depth of 15,000 feet.

The longest string of casing yet run was recently landed and cemented at a depth of 13,001 ft. in Standard Oil Company of California's No. 8 K.C.L. at Wasco. The total length was 13,019 ft, 18 ft. standing above the floor. This string was Spang Chalfant 7-in. O.D. Class X Extreme Line casing of several weights. (Table 1.) Although the total weight was 186.5 tons, it was not the heaviest string of pipe that has been run.

The casing was run inside a string of 10¾-in. that had been cemented at a depth of 7505 ft. and into 9⅝-in. hole drilled to a depth of 13,048 feet. The different weights shown in the table were run in the order indicated, the heaviest pipe on bottom. As the 30-lb. and 26-lb. sections constituting the upper portion of the string were subjected to the tensile stress imposed by the weight of the heavier section below, 100 percent joint efficiency was specified for these sections.

The string was floated-in to a depth of 2859 ft., the Baker float shoe on bottom and the float collar one joint above having a ball-type float and back-pressure valve. The fluid in the hole weighed approximately 90 lb. per cu. ft. and consisted of a mud made from clay to which Baroid, Aquagel, sodium tetraphosphate, Stabilite, and Brodreck had been added. The viscosity by Marsh funnel, 500 cc. in and out, ranged from 35 to 40 seconds. The hole had been reamed only at tight places by a reamer above the bit.

In cementing the pipe 1500 sacks of special oil well cement designed to reach its initial set in 3⅔ hours was used. It was estimated that 1200 sacks would fill the annular space between the 7-in. casing and the wall of the hole

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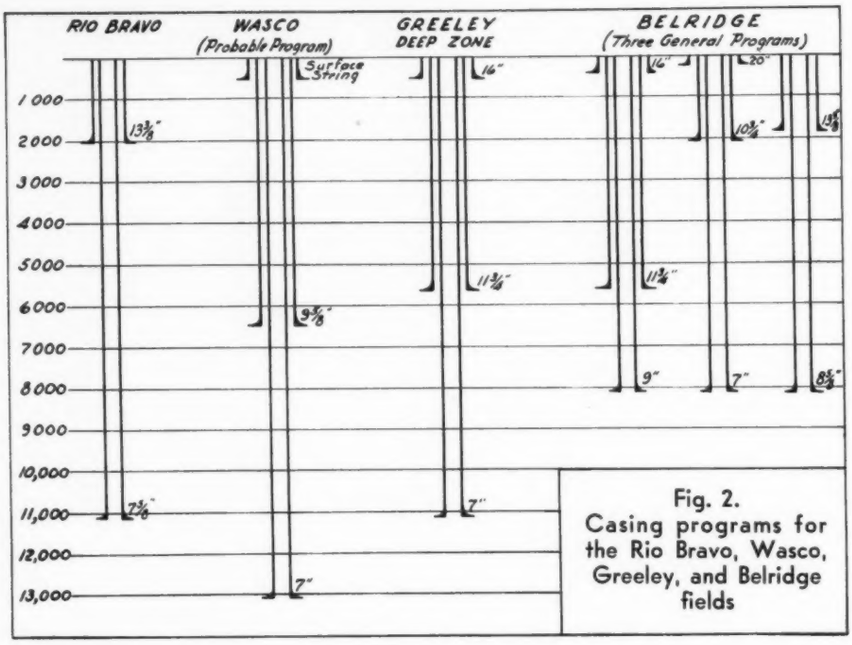


Fig. 2. Casing programs for the Rio Bravo, Wasco, Greeley, and Belridge fields

companies use 11¾-in. instead of 13⅜-in. and the water strings employed to date have been 6⅝-in., 7-in., and 7⅝-inch. One company uses a float shoe and two float collars on the 7⅝-in. string, one collar being placed one joint above the shoe and the other collar one joint above the first.

This company also spuds the 11,000-ft. string during the entire cementing operation. The pipe is not merely raised and lowered slowly but the engine is "kicked wide open" and the string rapidly raised 30 feet and then dropped and this performance is repeated continually.

There seems to be an inclination among other operators to move the pipe while cementing, even long strings in deep holes. Movement of the kind of casing now available is evidently comparatively safe when formation conditions permit. One operator at Kettleman Hills spuds 9⅝-in. casing while cementing at depths below 7500 feet.

to the shoe of the 10¾-in string. This would leave 300 sacks to provide for dissipation and cement left in the casing and to extend some distance between the 7-in. and 10¾-in. strings.

The cement was mixed to form a 118-lb. per cu. ft. slurry. The mixing pressure was 200 to 300 lb. per sq. in. and 43 minutes was required for mixing and placing the cement in the casing. During the cementing operation the pressure gradually increased to 1800 lb. before all the cement was placed. The connections were then changed to the cementing company's pumps (elapsed time, 7 minutes) and the pressure increased to 2500 lb. per sq. in. without extruding any more cement. Sufficient cement, however, had been placed around the pipe to fulfill the estimated requirements and the subsequent water shut-off test showed a complete shut-off.

The future casing program at Wasco will probably consist of a surface string of approximately 500 ft., 9⅝-in. to a depth between 6000 and 7000 ft., and a 7-in. water string to a depth of 13,000 feet. In the discovery well in this field the 7-in. casing was set at a depth of 11,573 ft., and at that time was the longest string of pipe run in California. Prior to the running of this 13,000-ft. string of 7-in. casing the longest string run was 12,215 ft. of 7-in. in Fohs Oil Company's No. 1 State Bay Baptiste in Louisiana.

At Rio Bravo the casing programs are in general as shown (Fig. 2). Some

Fig. 3. Looking up to the change in taper of a new derrick design

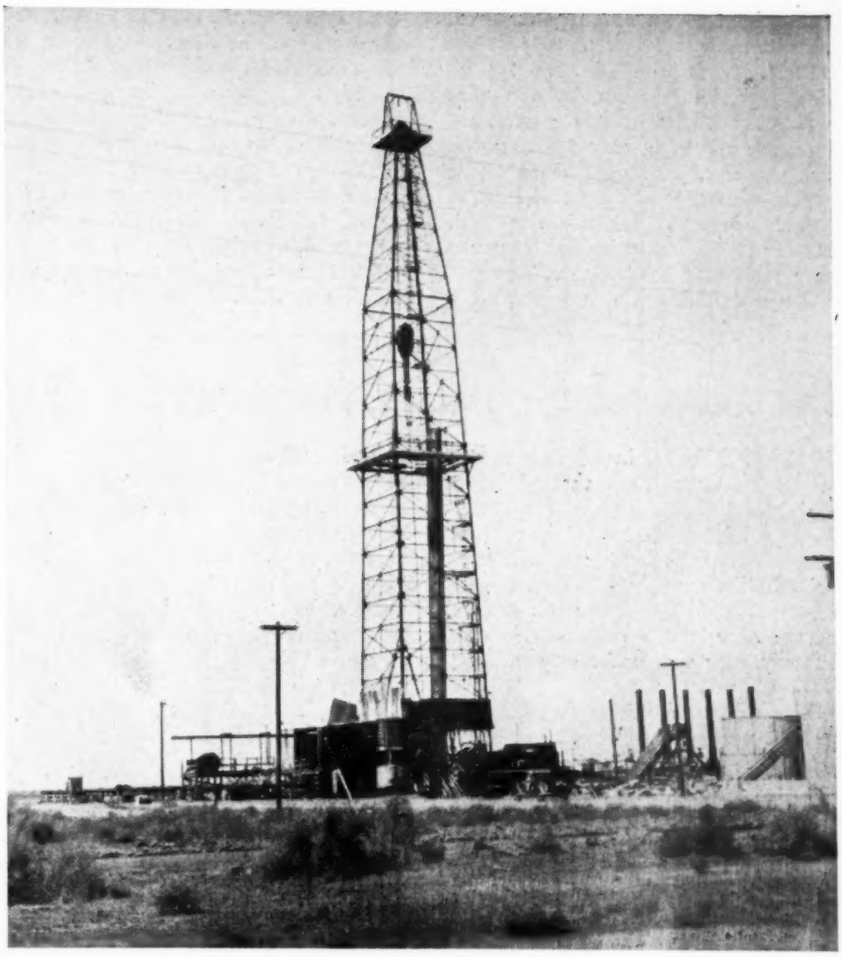


Fig. 4. Varying-taper derrick on Standard Oil Company's No. 1 Mushrush, Wasco field, California

The string is moved slowly, however, for a distance of only 15 feet. During the placement of the last 50 cu. ft. of cement the pipe is moved up and down only 3 or 4 ft. so that if it sticks it is near the cementing point.

When a float shoe and float collar are used it has become general practice to place the collar one full joint above the shoe. If the operator wants to leave more cement in the pipe to make sure that the cement around the shoe has no possible chance of being weak, the float collar is placed higher in the pipe to stop the plugs at a greater distance above the shoe. Few operators are placing the float collar less than one full joint above the shoe.

Two wells have been completed in the new deep zone at Greeley. The casing program is as shown (Fig. 2). The 11¾-in. string is set and cemented to protect the upper zone. The 7-in. string, which is set at a depth exceeding 11,000 ft., and the 11¾-in. string are both floated-in by float shoe and float collar.

Although Belridge is not a deep field compared to the others, the programs at Belridge are rather interesting. A bad muck necessitates the washing-in of the water string. The hole does not cave but the water filters from the fluid. In all three programs shown on the drawing the strings that are run to depths exceeding 8000 ft. are equipped with wash-down whirler float shoes, which force the fluid to spiral downward around the shoe to keep it from hanging or sticking.

In the program shown on the left the 9-in. casing, which is Extreme Line, is run in a 10⅝-in. hole. In the other programs the clearance is greater, the 7-in. string being run in 9⅝-in. hole and the 8⅝-in. string in 12¼-in. hole. This last string is Hydril flush joint.

In cementing these water strings 2000 sacks are used and no trouble is experienced. Pressures usually required range from 1800 to 2400 lb. per sq. in. and the cement is followed by 120-lb. mud to offset formation pressure.

In all these fields it is general practice merely to break circulation and then immediately pull the head and start cementing. It is assumed that any necessary cleaning will be done by the fluid preceding the slurry.

Derricks

Although shorter derricks are adequate for supporting the loads, the 178-ft. derrick is used extensively for drilling in deep fields such as Rio Bravo and Wasco. A derrick of this height and 32-ft. base has the capacity to accommodate 120-ft. stands of drill pipe and the increased speed permitted in making round trips is the outstanding advantage. In a recent paper on "Modern Trend in Drilling Equipment," however, A. H. Bell[1] has stated:

"The 122-ft. derrick with safe load capacity of 465,000 lb. is ample for any loading that may be expected in drilling to the greatest depth yet attained so that the extra cost of the 178-ft. derrick can only be charged to saving in drilling time, which in this case would be saving in time making round trips. Preliminary time studies indicate that between a 136-ft. derrick using a 12 by 12-in. engine and 250-lb. superheated steam and a 178-ft. derrick using a 14 by 14-in. engine and 350-lb. superheated steam the saving in time running drill pipe at about 10,000 ft. depth amounted to only 3.7 minutes per thousand feet coming out and 3.2 minutes per thousand feet going in.

"Assuming the maximum number of round trips that might be expected in drilling to 13,000 ft. this only gives a saving of $3500 per well for the high derrick and hardly justifies the additional costs for the entire set-up. Greater speed in making round trips might be of inestimable value in the event of a fishing job or in a race to tap a competitive pool with large wells not restricted by proration regulations.

[1]Paper presented at the Los Angeles meeting of A.I.M.E., October 20, 1938.

TABLE I

Weight of casing, lb.	No. of joints	Total length, ft.	O. D. of joints, in.	I. D. of joint-, in.	O. D. of pipe, in.	I. D. of pipe, in.	Total weight, lb.
38.0	15	630.69	7.390	5.815	7.00	5.920	23,966.22
35.3	58	2,396.00	7.390	5.895	7.00	6.000	84,578.80
30.0	68	2,766.22	7.390	6.049	7.00	6.154	72,986.60
26.0	157	6,331.60	7.390	6.049	7.00	6.276	164,621.60
30.0	22	894.54	7.390	6.049	7.00	6.154	26,836.20
	320	13,019.05					372,989.42

It has been found necessary to install an intermediate finger to support the 120-ft. stands of 4½-in. and 5 9/16-in. drill pipe, but the 3½-in. drill pipe will not rack without damage and most operators are using only 90-ft. stands for this size. This nullifies any time saving advantage of the tall derrick in round trip speed for this size pipe. However, various possible remedies may solve this disadvantage."

Large derrick floors, however, are a convenience for the crew and facilitate the work on the floor. More room is also available for racking pipe. As mentioned, two fingers are being used to support the smaller drill pipe in order to eliminate the belly that forms when 120-ft. stands are racked. The extra finger, however, does not permit the use of 120-ft. stands of 3½-in. drill pipe, which, being the size used at greatest depths, requires more room on the derrick floor.

At Wasco one 178-ft. derrick of the new type of varying taper (Fig. 4) is being used in drilling one well. This design provides for racking larger areas of pipe but also provides ample working space at all points inside the derrick. The base is 26 ft. and the taper in 132 ft. is only 4 feet.

In running casing in all the deep wells ten lines are being used, although eight lines are used in drilling.

Study of Foraminifera Is Aid to Engineers

PROSPECTIVE benefits to scientists and engineers through cataloging of hitherto unorganized literature pertaining to foraminifera, best known of all the index fossils, is outlined in the recently published annual report of a geological research project of the American Museum of Natural History, now well under way in New York City.

The report of this undertaking to provide a comprehensive catalog, bibliography, and atlas of the genera and species of foraminifera, calls attention to the importance of these minute animals that offer the key by which subsurface conditions in any given community may be determined.

Sponsoring the project for a geographic catalog and a geographic atlas of foraminifera is the American Museum of Natural History, with New York University as a coöperating agent and the American Museum, New York University, and Columbia University libraries as coöperating libraries.

The report explains that foraminifera have been marine inhabitants throughout geologic time, that their shells have been buried in the sediments deposited in ancient seas, and that it is these sediments, consolidated in rock, that comprise most of the surface of the earth and extend far underground in complicated series.

In other words, the report points out, foraminifera serve the same purpose for the geologist and engineer that X-ray pictures do for the physician; they give a picture of what may be encountered. Unfortunately, however, the literature of the world on this important subject has been in such a jumbled state that it has been difficult for scientists to make full use of it.

The report is a handsomely printed and bound volume, extensively illustrated. Of the project itself, it comments:

"The most obvious and immediate value of the results produced by this project will be the stimulus given research in micropaleontology and stratigraphy. Though at present there are only a few advantageously located specialists who can do productive work with this group of organisms, the number will be increased a thousand-fold by the publication of the results achieved by the present undertaking.

"There are today literally hundreds of thoroughly competent, well-trained workers who are isolated in small colleges and laboratories throughout the country, and, therefore, do not have access to the literature so necessary to productive research. This compilation will place in their hands the systematized, organized literature of the world on this subject."

The report dwells too on the potential immediate practical effect of the work, commenting that "in the field of applied science the undertaking promises to be especially beneficial. This is particularly true in the petroleum industry where foraminifera have been used since 1917 in the solution of problems dealing with the accumulation of oil and natural gas."

In addition to the benefits to science and engineering, the project is providing employment for a group of well-educated, and in some cases highly-trained, workers who for various reasons were forced to the relief rolls. No difficulty was encountered in finding eligible persons with the desired training for most of the work, and in this connection the report comments:

"The project now has some 130 workers listed . . . These individuals have been selected from hundreds of applicants and consequently represent the best material available on the Works Progress Administration rolls of New York City. Many have worked for years at their profession or trade before coming to this organization. Others have come to the project directly from college classrooms or trade schools; a few have received all their training here. But whether the latter is the case, or whether they are older people with a lifetime of training and experience behind them, all are now well suited to carry on the work they are doing. This makes for a compact, effective group.

"Among the older people quite a few have truly astonishing qualifications. A knowledge of languages is quite essential in this type of work and some individuals on the project are proficient in as many as ten different tongues."

The number of unemployed persons with training in geology in New York City is large, partly because many women who majored in the subject in the various colleges and universities were unable to do field work, and, consequently, were unable to obtain regular positions.

Trained workers for some aspects of the undertaking were not to be found on relief rolls, however, and, to meet this situation, promising individuals were trained for the particular jobs they were to fill. This was true with respect to photostat operators, bookbinders, photographers, and varitype operators.

Foraminifera, being splendid indicators of subsurface conditions, have been used to advantage in connection with such engineering projects in and about New York City as the water supply system, bridge pier foundations, Midtown Tunnel, and certain harbor developments.

In addition to foraminifera, it is the aim of the present undertaking to systematize the literature of other microfossil groups such as the ostracods, bryozoans, diatoms, and radiolarians, which also is in a chaotic condition.

A companion project to the work of cataloging calls for compilation of a geologic atlas to show the geographic distribution of individual species and genera of foraminifera both in maps and in charts. Most of the essential information already is in the files of the Geologic Catalog but a vast amount of work remains to be done in selection and integration of significant portions. At present, 42 persons are employed on the geologic atlas project.

Cleaning Heat Transfer Equipment

Proper application of heat exchange and maintenance of efficiency of equipment essential to economical refinery operation

By G. RUSSELL HERSAM[1]

THE economical operation of an oil refinery is dependent to a large extent upon the proper application of heat exchange and often the operation, maintenance, and design of heating equipment are the major responsibilities of the process engineer. As actual plant conditions vary widely the correct design, selection, and care of heat exchange equipment can rarely be standardized. The fundamental aim in the design and application of such equipment is to construct and place the unit to obtain maximum heat transfer without interfering with the special requirements exacted of the particular piece of equipment.

To maintain efficiency of operation it is important that the rate of heat transfer is not appreciably impaired once the equipment is placed in service. It is well known, however, that from the moment heat exchange units are placed in use, whether they are process exchangers, preheaters, condensers, steam generators, dephlegmators, or other heating equipment, the heat transfer rate steadily decreases because foreign materials deposited on tube surfaces have an insulating effect and retard heat flow. Such a decrease in heat transference naturally tends to lower operating efficiency and in turn increase production cost. When it is considered that in a distillation unit one of the principal purposes of heat exchange is to reduce furnace duty, then it may be readily understood why the accumulation of heat-transfer-reducing deposits can materially affect the economy of the process.

Fouling of the surfaces of equipment also retards fluid flow and makes it necessary to maintain higher pump pressures than normally required. These fouling deposits may even completely clog the tubes, preventing flow.

Nature of Fouling Deposits

Because of the numerous applications of heat exchange, special local problems, and the wide variety of crude oils, a discussion of the exact nature of these deposits that retard flow of both heat and fluid is difficult. That the nature of these deposits is also influenced by temperature contributes further to the complexity of the problem. In fact, it is quite probable that in no two processing methods is the condition of these deposits exactly the same.

Despite the many individual conditions of fouling, the deposits in a general way may be classified into two types as follows:

1. Oil residues—this type may generally be considered as consisting of combinations of burnt-on oils, sludges, silt, soot, carbon, coke, or other oil decomposition products.

2. Scales—examples of this type are water scale, corrosion scale, and rust. Whenever water is employed as a cooling medium, whether it be in the refinery or elsewhere, invariably scale is deposited on the metal surfaces. These water scale deposits may be of organic origin, a true mineral scale, or a combination of the two. The impurities usually present in water are silica and the salts of calcium, magnesium, iron, and sodium, and these compounds form true mineral scale. On the other hand, the presence of microscopic organisms in water-cooling systems is made manifest by slime and algae that also are a contributing factor in reducing the rate of heat transfer.

It is possible to classify these deposits as (1) hard deposits, (2) porous deposits, and (3) loose deposits. Nelson[2] has pointed out that the porous "deposits may be more serious than hard scales because the fluid that is contained in the porous material usually has a lower conductivity than the hard skeleton of the scale, and thus the over-all conductivity is low". Therefore the actual condition of the deposit is an important factor.

Combinations of oil-residue deposits and scale deposits are also common; the presence of certain salts in crude oil is well known and they present to the refiner one of his most serious problems. These salts are mainly the chlorides of sodium, calcium, and magnesium and their deposition on tube surfaces will mechanically clog the tubes.

Nelson[3], after a theoretical discussion of fouling, concludes that "the heat transfer equipment should be systematically cleaned if best results are to be obtained. Under some conditions the equipment should be cleaned daily while in others cleaning at intervals of four to six weeks may be economical. Plant experience with the particular conditions can be the only guide in the matter."

Cleaning Methods

Many methods are employed in the cleaning of heat exchange equipment. The oldest and probably most common practice has been that of drilling or rodding the tubes by mechanical means. This is a tedious manual operation and is far from being the most practical. Design of modern refinery equipment involves the use of numer-

[1]Oakite Products, Inc.

[2]Nelson, W. L., Ref. Nat. Gaso. Mfr. 13, 7, 273 (1934).

[3]Nelson, W. L., Ref. Nat. Gaso. Mfr. 13, 8, 298 (1934).

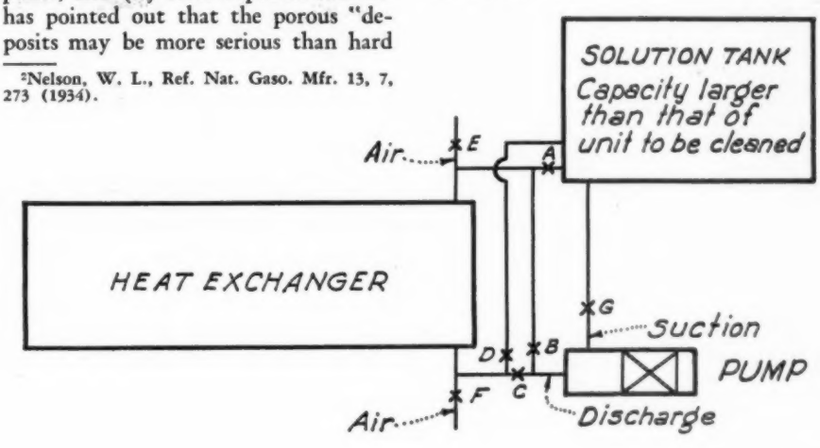
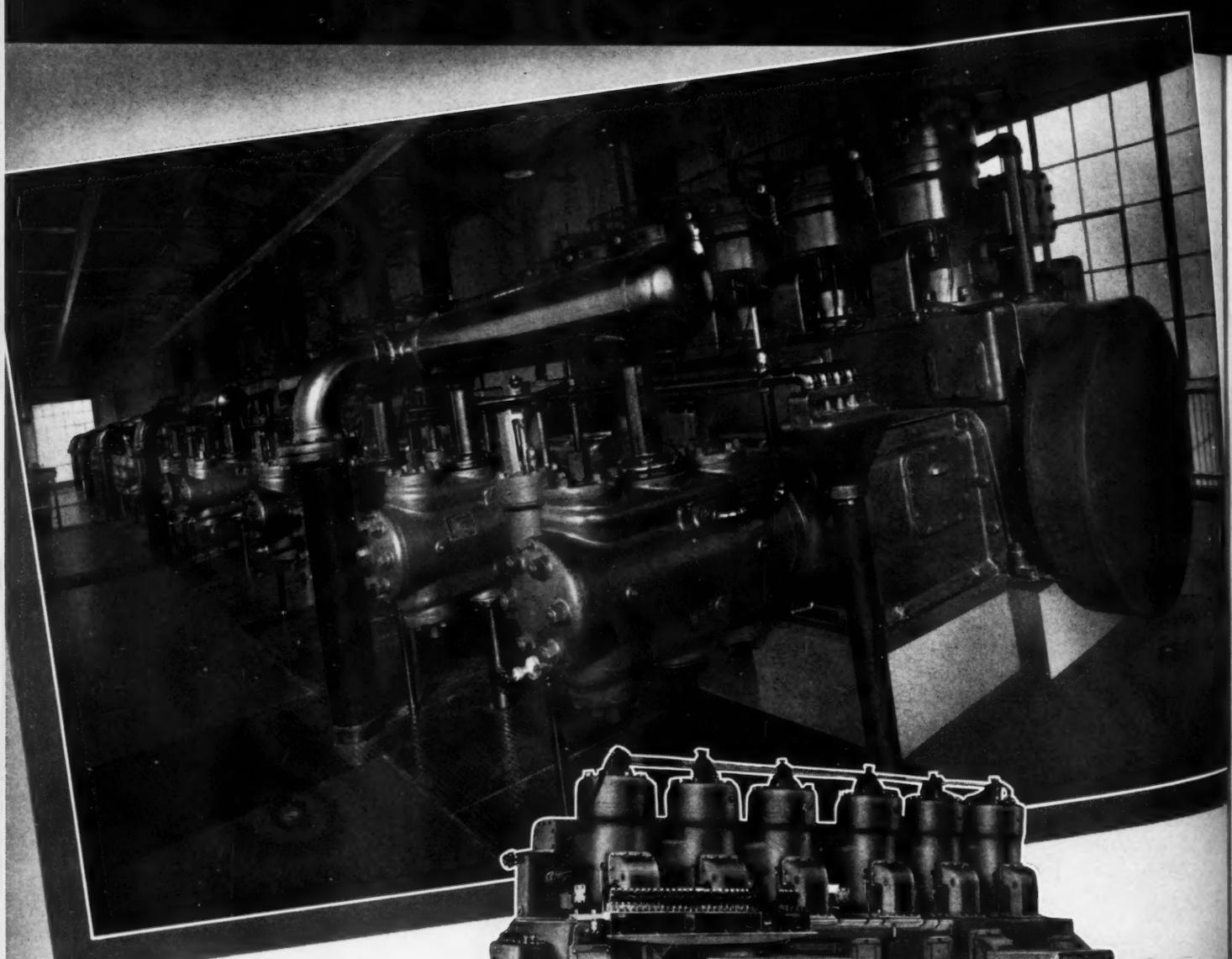
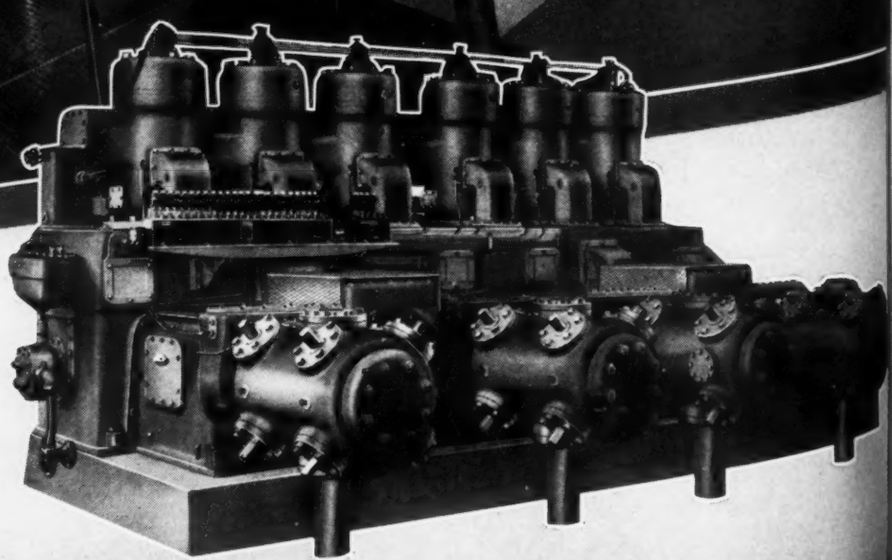


Diagram of simple hook-up used in the circulating method of cleaning heat exchangers

"Performance exceeded our





Battery of 5 CLARK 600 H.P. Super-2-Cycle "Angle" Compressors, Memphis Natural Gas Company Booster Station, Wilmot, Arkansas.

•

At right: 6-cylinder, 600 H.P. CLARK "Angle." Also built in 2, 3, 4, and 5-cylinder sizes, ranging from 200 to 500 H.P.

of the station expectations"

writes H. C. Wallace,
Vice-President, Memphis Natural Gas Co.

IN response to an inquiry regarding the performance of the CLARK "Angle" Compressors at the Wilmot, Arkansas, Booster Station of the Memphis Natural Gas Company—H. C. Wallace, Vice-President of the company, writes us:

"Replying to your inquiry concerning the performance of Clark "Angle" Compressors and our opinion of this equipment:

"As you know, in the summer of 1937 we constructed a compressor station on our main line at Wilmot, Arkansas, equipped with five 600 H. P. Clark "Angle" machines. This station was completed in the fall and placed in service December 1, and was operated at capacity from then on through the period of our heavy peak demands until about March 15. During this time we experienced no operating difficulties of any kind, and the performance of the station generally exceeded our expectations. We found this equipment particularly adaptable to our service due to the flexibility of the units and the short time required for them to come on and go off the line.

"By the use of this equipment at this particular point we were able to effect a considerable saving, due to the compact design of the plant, which was made possible by the use of this particular type of equipment.

"This summer we have inspected the compressors and gas engines carefully and find that there has been no appreciable wear due to the season's operation, and nothing but ordinary maintenance has been required. As a result of this first year's experience, we believe that your prediction regarding low maintenance cost at this station will be realized."

CLARK "Angles" are bringing users three great savings: On Installation cost because compact design saves on transportation, foundations, and building; on Operation because CLARK Super-2-Cycle Fuel Injection saves 1/3 on fuel, giving 4-cycle fuel economy; on Maintenance due to the rugged simplicity of CLARK 2-cycle design.

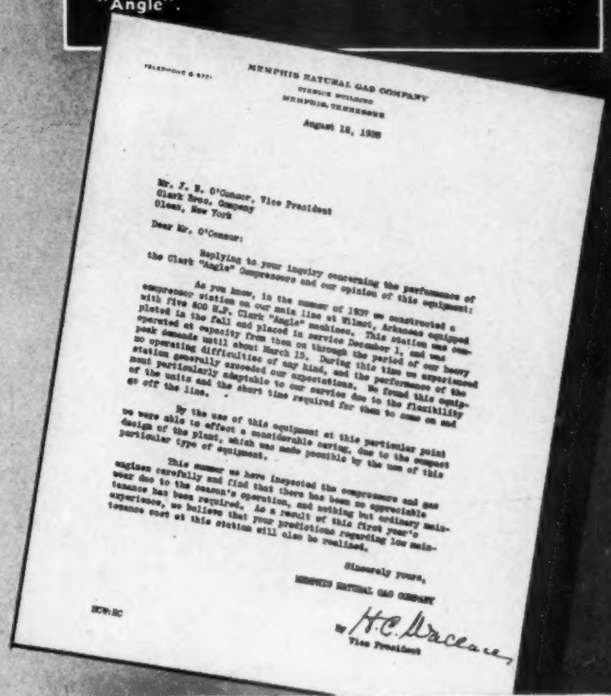
Write for our new catalog; also our 20-page booklet giving complete engineering description of the Wilmot Station.

CLARK BROS. COMPANY . . Olean, New York, U. S. A.

Export Office: 30 Rockefeller Plaza, New York. Midcontinent Sales Offices and Warehouses: Tulsa, Okla.; Dallas and Houston, Texas. West Coast Office: Smith-Booth-Usher, 2001 Santa Fe Ave., Los Angeles. Foreign Offices: 72 Turnmill St., E. C. 1. London, England; 4 Str. General Poetas, Bucharest, Roumania.

CLARK

Main Compressor Building and Meter House, Wilmot Station. Note saving in size of building made possible by compact design of the CLARK "Angle".



MEMPHIS NATURAL GAS COMPANY
UNION BUILDING
MEMPHIS, TENNESSEE

August 18, 1938

Mr. J. B. O'Connor, Vice President
Clark Bros. Company
Olean, New York

Dear Mr. O'Connor:

Replying to your inquiry concerning the performance of the Clark "Angle" Compressors and our opinion of this equipment:

As you know, in the summer of 1937 we constructed a compressor station on our main line at Wilmot, Arkansas equipped with five 600 H.P. Clark "Angle" machines. This station was completed in the fall and placed in service December 1, and was operated at capacity from then on through the period of our heavy peak demands until about March 15. During this time we experienced no operating difficulties of any kind, and the performance of the station generally exceeded our expectations. We found this equipment particularly adaptable to our service due to the flexibility of the units and the short time required for them to come on and go off the line.

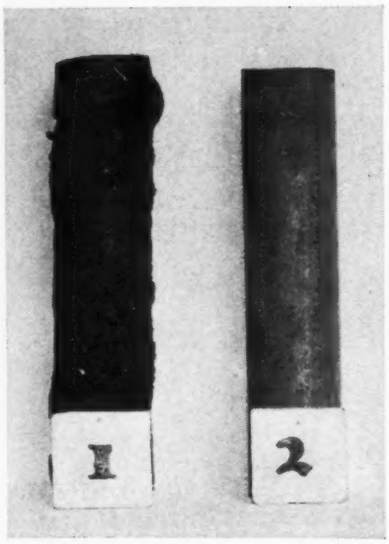
By the use of this equipment at this particular point we were able to effect a considerable saving, due to the compact design of the plant, which was made possible by the use of this particular type of equipment.

This summer we have inspected the compressors and gas engines carefully and find that there has been no appreciable wear due to the season's operation, and nothing but ordinary maintenance has been required. As a result of this first year's experience, we believe that your prediction regarding low maintenance cost at this station will also be realized.

Sincerely yours,
MEMPHIS NATURAL GAS COMPANY
By H. C. Wallace
Vice President

HCW:BC

General view of Wilmot Station, showing cooling tower, main compressor building and auxiliary building.



Tests in the laboratory assist in selecting best solution to soak deposits from outside of exchanger tubes. (1) Before. (2) After treatment

ous small tubes in shell-and-tube type heat exchangers. The tubes are mainly ⅝-in., ¾-in., and 1-in. O.D., and of various lengths to meet the specific conditions of operation, and the walls of these tubes are necessarily thin. When drilling or rodding-out is used to remove the more resistant deposits there is great danger of cutting these thin walls. It has been established that use of such mechanical means of cleaning tubes may necessitate replacement of tubes after only brief service. Often the expense involved in replacing condenser tubes or tubes of similar equipment, as well as the time required for replacement, become important items in refinery economics. This would be especially true of a gasoline-vapor-crude-oil heat exchanger where tube failures result in a shut-down, as vapor line by-passes are expensive and not generally used.

Circulation of muriatic acid at different concentrations as an alternate method for the removal of hard water scale deposits also has its disadvantages, the principal one being that this acid readily attacks iron or steel, reducing it after a time to a material easily punctured. Specialized research, however, has developed inhibited acids that not only do a better job than muriatic but also do not attack the metal appreciably.

Soft and loose deposits, such as sludges, and the softer oil residues are often removed by blowing hot water or steam through the unit. Soft scales may sometimes be removed more or less effectively by swabs. Still another method of cleaning is to force plastic plugs through the tubes by compressed air, steam pressure, or water pressure, but experience has shown that this method, also, is effective for removing only the soft sludge-like deposits. Until recently hard deposits could be removed only by drilling or the use of raw acids.

Mechanical cleaning methods often present many disadvantages in addition to those already mentioned. The location of some heat exchange units renders them inaccessible for cleaning, making the removal of heads and pulling of tube bundles an awkward job, sometimes necessitating the use of cranes or similar equipment. In addition, mechanical methods are not adaptable for effective removal of encrusted deposits on the outer surface of the tubes and it is almost essential that the more modern chemical cleaning methods be employed.

It is a recognized fact that when the tubes of a heat exchanger are cleaned by mechanical methods, even under the most favorable conditions, only part of the fouling deposit is removed and as a result there is still a considerable loss of heat transference.

Modern Cleaning Compounds

The last decade has seen the development of various compounds, the characteristic of which is ability to loosen and remove foreign deposits without corroding equipment. Such compounds are adaptable to a wide variety of applications in the processing plant and are not restricted to the cleaning of heat exchange equipment. Stills, absorption towers, etc., need frequent cleaning and some entire plants become fouled with oil residue and scale deposits. The correct choice and application of materials permits cleaning in a single operation.

The method consists of circulating through the system a solution of that cleaning compound found capable of doing the particular job. After repeated circulations, first in one direction and then in the other, the solution is drained from the unit, which is then thoroughly flushed either with steam or water, until inspection of the water leaving the system reveals that all loosened deposits have been removed. It is advantageous to agitate the cleaning solution violently. For dislodging and removing insoluble carbon particles this agitation is essential. During the entire operation the temperature of the cleaning solution should be as near the boiling point as possible. The solution is contained in a large holding tank and the temperature maintained at the boiling point by means of closed steam coils. Open steam coils cause dilution of the solution and waste of cleaning material. Most exchangers and similar equipment are lagged so that once the solution has been raised to the proper temperature little trouble is experienced in maintaining it.

There are two major factors that may mean the difference between success and failure when refinery equipment is cleaned by this method.

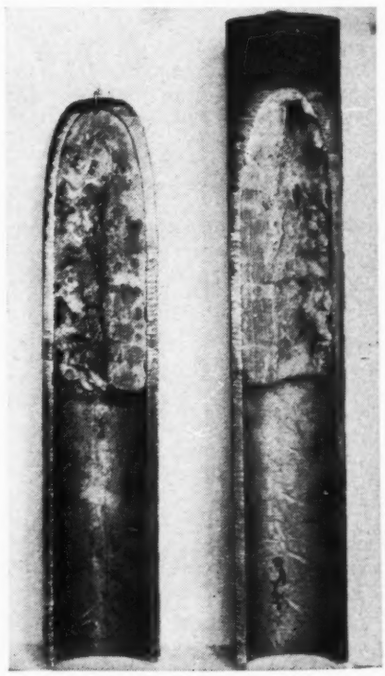
1. The employment of materials best suited for the problem at hand.
2. The proper equipment properly installed.

In addition, it is essential that an adequate cleaning procedure be followed and because of the wide range of conditions this is a problem that can be solved only on the job. It may be best to remove the tube bundle and immerse it in a vat containing the chemical solution. Usually, however, methods can be devised for cleaning the various heating units without dismantling.

When tubes have become completely plugged it is necessary to remove the header and rod-out each tube before circulating the cleaning solution. A plant operating on a specific cleaning schedule should never find it necessary to resort to inefficient mechanical drilling methods.

Some refineries are finding it good practice to operate extra sets of certain heat exchange equipment. Operators of

Although the interior of tubes can be drilled or rodded-out, much less work and wear-and-tear are involved if the deposit is dissolved. Lower sections of these tubes cleaned by soaking illustrate the results



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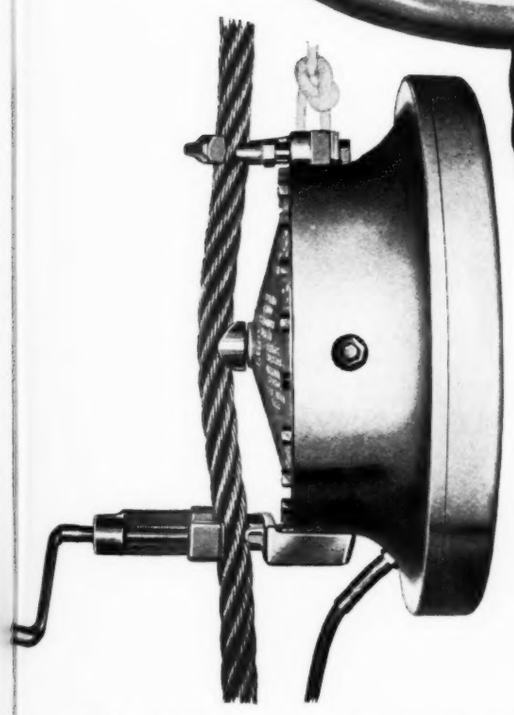

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one plant report that an extra set of coolers on top of the dephlegmator tower eliminates one source of maintenance trouble. This additional set of coolers permits the vapors to be excluded from either set without interrupting the operation of the other and consequently there is no loss of production. In this manner equipment can be cleaned without interfering with production. It is possible that designs of the future will make use of similar modifications to facilitate cleaning of equipment.

A permanent installation of cleaning equipment is highly recommended. Experience has shown that it easily pays for itself in the long run. Moreover, permanent installations may not necessarily mean an outlay for new and expensive equipment, for the necessary items can usually be salvaged from present equipment not in use. The cleaning solutions may be used many times by adding small amounts of material to recondition the solution for the next job. After a solution has been used several times, the heavy muck removed from the heating equipment may be drawn off, cleaning the solution.

Equipment Design and Cleaning Schedule

The entire problem of efficient operation of heat transfer equipment can be reduced to two fundamentals, simple in principle but requiring skill and experience in actual practice.

(1) The first fundamental is the design of the equipment itself. Authorities on design of heat exchange equipment point out the difficulty of obtaining reliable estimates of the fouling rate under many different operating conditions and, therefore, the complicated problem of the original design and installation. The designer naturally endeavors to allow for some fouling.

(2) Maintenance of efficient operation of heat transfer equipment, however, is only possible through the use of a regular schedule of thorough cleaning frequently enough that the equipment does not become badly fouled. Obviously, the method must be economical, low in labor cost, and one that will provide minimum interruption to service.

Oil From Recently Discovered California Field Analyzed by Bureau of Mines

THE crude oil produced from the recently discovered deep pay zone (Avenal sand presumably of Eocene age) in the Eastside Coalinga field, Fresno County, California, is an intermediate base oil having a gravity of 33.4 deg. A.P.I., and a sulphur content of 0.22 percent, according to an analysis made by the U. S. Bureau of Mines, on a sample obtained from No. 1 Gatchell, completed during June, 1938, at a total depth of 6908 ft., in producing formation topped at 6814 feet.

The distillation summary of the oil includes 26.9 percent gasoline and naphtha, 4.4 percent kerosene distillate, 22.6 percent gas oil, and 20.2 percent heavier distillates.

For the last 30 years wells on land immediately adjacent have been producing a good grade of refining oil from depths of 1400 to 3500 feet. A composite sample of oil from the Eastside Coalinga field collected by the Bureau of Mines in 1928 had a gravity of 24.0 deg. A.P.I. and a sulphur content of 0.45 percent. The distillation summary of that oil includes 14.7 percent gasoline and naphtha, no kerosene distillate, 29.4 percent gas oil, and 23.7 percent heavier distillates.

The No. 1 Gatchell has been estimated to have a potential production of 20,000 bbl. per day. Since it was brought in three additional wells have been completed in the immediate vicinity each of which is believed to have a potential equal to that of the discovery well. The potentials of these latter wells were not determined definitely, the wells having been restricted to a small prorated production immediately on being completed. Whether or not the productive area will prove extensive is yet to be determined.

The complete analysis follows:

No. 1 Gatchell 6814-6908 feet.
Eastside Coalinga Field, Avenal (Eocene) Formation, California, Fresno County.

GENERAL CHARACTERISTICS

Specific gravity, 0.858.
Sulphur percent, 0.22.
Saybolt Universal viscosity at 77 deg. fahr., 49 sec.
Saybolt Universal viscosity at 100 deg. fahr., 44 sec.
A.P.I. gravity, 33.4 deg.
Color, greenish black.

DISTILLATION, BUREAU OF MINES HEMPEL METHOD

Distillation at atmospheric pressure
Barometer 742 mm. First drop: 29 deg. cent. (84 deg. fahr.)

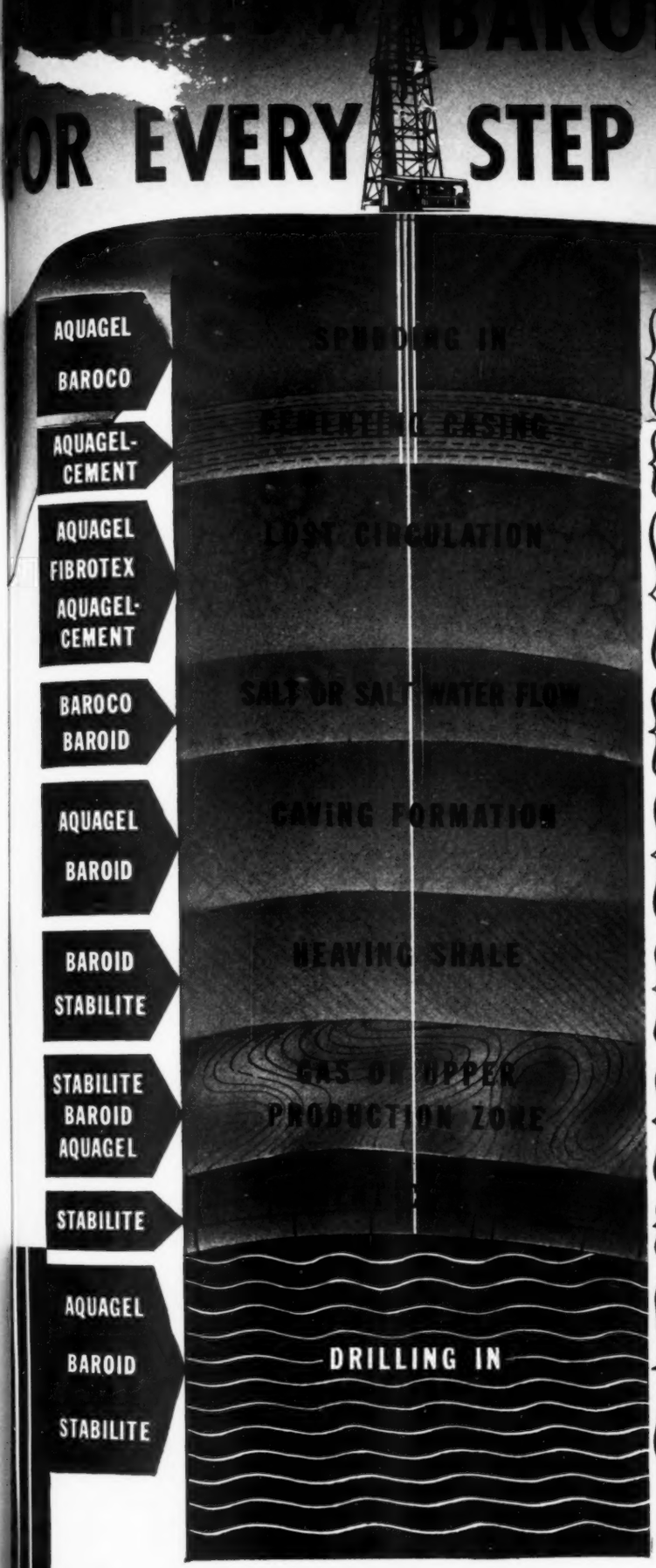
Temperature, deg. cent.	*Percent cut*	*Sum, percent*	*Specific gravity of cut*	*Deg. A.P.I. of cut*	*Viscosity at 100 deg. fahr.*	*Cloud test, deg. fahr.*	*Temperature deg. fahr.*
Up to 50	----	------	------	------	------	------	Up to 122
50- 75	3.3	3.3	0.656	84.2	------	------	122-167
75-100	4.3	7.6	.731	62.1	------	------	167-212
100-125	6.0	13.6	.759	54.9	------	------	212-257
125-150	5.0	18.6	.777	50.6	------	------	257-302
150-175	4.3	22.9	.792	47.2	------	------	302-347
200-225	4.4	31.3	.823	40.4	------	------	392-437
175-200	4.0	26.9	.807	43.8	------	------	347-392
225-250	5.8	37.1	.839	37.2	------	------	437-482
250-275	7.7	44.8	.853	34.4	------	------	482-527
Vacuum distillation at 40 mm.							
Up to 200	4.5	4.5	0.870	31.1	40	15	Up to 392
200-225	6.4	10.9	.874	30.4	47	35	392-437
225-250	6.2	17.1	.888	27.9	61	55	437-482
250-275	5.5	22.6	.898	26.1	93	75	482-527
275-300	6.7	29.3	.910	24.0	180	90	527-572

Carbon residue of residuum, 9.4 percent; carbon residue of crude, 2.2 percent.

APPROXIMATE SUMMARY

	Percent	*Sp. gr.*	*Deg. A.P.I.*	*Viscosity*
Light gasoline	7.0	0.698	71.2	------
Total gasoline and naphtha . . .	26.9	0.758	55.2	------
Kerosene distillate	4.4	.823	40.4	------
Gas oil	22.6	.857	33.6	------
Nonviscous lubricating distillate .	11.3	.877-.899	29.9-25.9	50-100
Medium lubricating distillate . .	7.0	.899-.913	25.9-23.5	100-200
Viscous lubricating distillate . .	1.9	.913-.917	23.5-22.8	Above 200
Residuum	23.0	.973	13.9	------
Distillation loss	2.9	------	------	------

BAROID PRODUCTS FOR EVERY STEP IN DRILLING



Aquagel—Concentrated colloidal gel-forming clay. One ton makes about 150 barrels of excellent drilling fluid when mixed with fresh water.

Baroco—For use where water is contaminated with salt.

Aquagel-Cement—Gives a better bond between casing and hole, improving shut-off of gas, water, or oil.

Aquagel—In proper concentration often prevents or restores loss of circulation.

Fibrotex—12 to 14 lbs. of **Fibrotex** per barrel of mud provide unusual sealing qualities.

Aquagel-Cement—Possesses unusual ability to plug creviced or cavernous areas. Does not flow out like neat cement.

Baroco—Maintains viscosity and wall-building properties in the presence of salt.

Baroid—Muds suitably weighted with **Baroid** counterbalance the pressures from salt water flows.

Aquagel—By preventing the penetration of water, the use of **Aquagel** frequently eliminates the tendency of formations to cave.

Baroid—Muds weighted with **Baroid** have demonstrated their efficiency in holding caving formations in place.

Baroid—Muds can be made up to high weights for the control of heaving or disintegrating shale.

Stabilite—The improved chemical thinner—maintains workable viscosities even though highly weighted muds are used in shale areas.

Stabilite—Frees entrained gas and reduces viscosity.

Baroid—Pumpable muds weighing as much as 145 lbs. per cubic foot can be made with **Baroid**.

Aquagel—Helps prevent the filtration of water into formations.

Stabilite—Often prevents discarding cement-cut mud by reducing viscosity and restoring wall-building properties.

Aquagel—Wells drilled in with straight **Aquagel** water mud in low pressure areas, swab on production and clean up quicker because the thin, impervious mud cake is very easy to remove.

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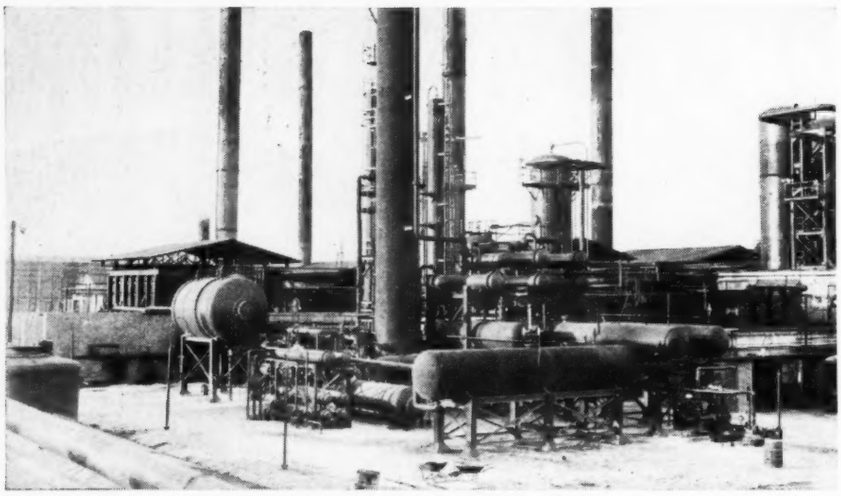


Polymerization plant of Atlas Pipe Line Corporation

By
J. C. ALBRIGHT

Addition of "poly gas" increases octane number and volatility of gasoline produced

Gases from Skimming and Cracking Units Are Polymerized to Form Gasoline

A CRACKING plant and polymerization unit owned by Atlas Pipe Line Corporation have been operating at Jewella, Louisiana, a suburb of Shreveport, for the last few years, skimming and cracking crude oil produced in various parts of Louisiana, East Texas, and southern Arkansas, including the Schuler field, west of El Dorado. Oil from this field contains some salt, and the uncondensed gases removed from the pressure-distillate run-down receiver drums contain as much as 480 grains of hydrogen sulphide per 100 cu. feet.

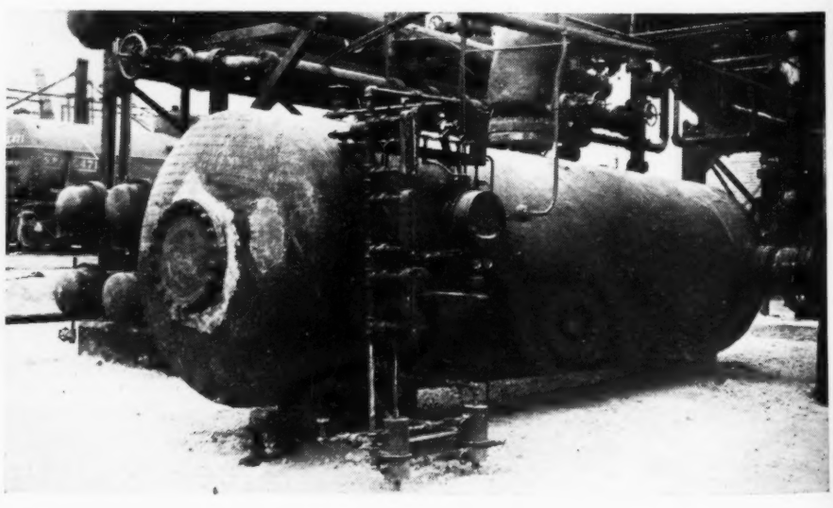
The crude oil, containing emulsions and salt, is processed as it comes from the pipe line by a battery of four electric desalting units. It is then topped in a battery of up-to-date shell stills, equipped with modern instruments for control of temperature, pressure, and throughput. The topped crude is pumped to the twin Gyro cracking units, where it is converted to industrial fuel oil, high octane gasoline, and unsaturated gases, which are subsequently compressed, condensed, and fractionated, mainly for use as charging stock in the Alco-Pure polymerization unit.

The maximum amount of gas produced is about 3,720,000 cu. ft. per day for the entire cracking unit, No. 1 unit producing about 72,000 cu. ft. per hour and No. 2 unit producing about 83,000 cu. ft. per hour. The gas is compressed by gas-engine-driven compressors. The gas is accumulated for compression from cracking plant pressure-distillate receivers, poly feed gas separators, and Gyro distillate work tanks. Approximately 264,000 cu. ft. of recycle gas from the stabilizer reflux accumulator drum increases to 3,984,000 cu. ft. the total volume of gas compressed per day.

The gas-engine-driven compressors are twin-tandem, double-acting and are equipped with high- and low-pressure cylinders. The low-pressure discharge pressure is about 65 lb. gauge, and the low-pressure suction about 8 pounds. All gas is scrubbed by contact with caustic soda to remove H_2S before it enters the compressor intake, to prevent corrosion of equipment. Gas from the first stage is cooled to a temperature of 80 deg. fahr., and then flows into the suction header to the high-pressure stage where low-boiling fractions are completely liquefied at pressures of about 450 pounds.

Two accumulator vessels receive condensate from condensing sections and other equipment. Liquids from the first or low-pressure cooling sections are pumped to the high-pressure drum on the second stage. Uncondensed gases such as those from separators on poly accumulator drums are fed to two absorbers, when pressures warrant, to recover products and fractions that may be further processed. Other gases recovered from various parts of the plant enter either the first or second stage as pressures warrant.

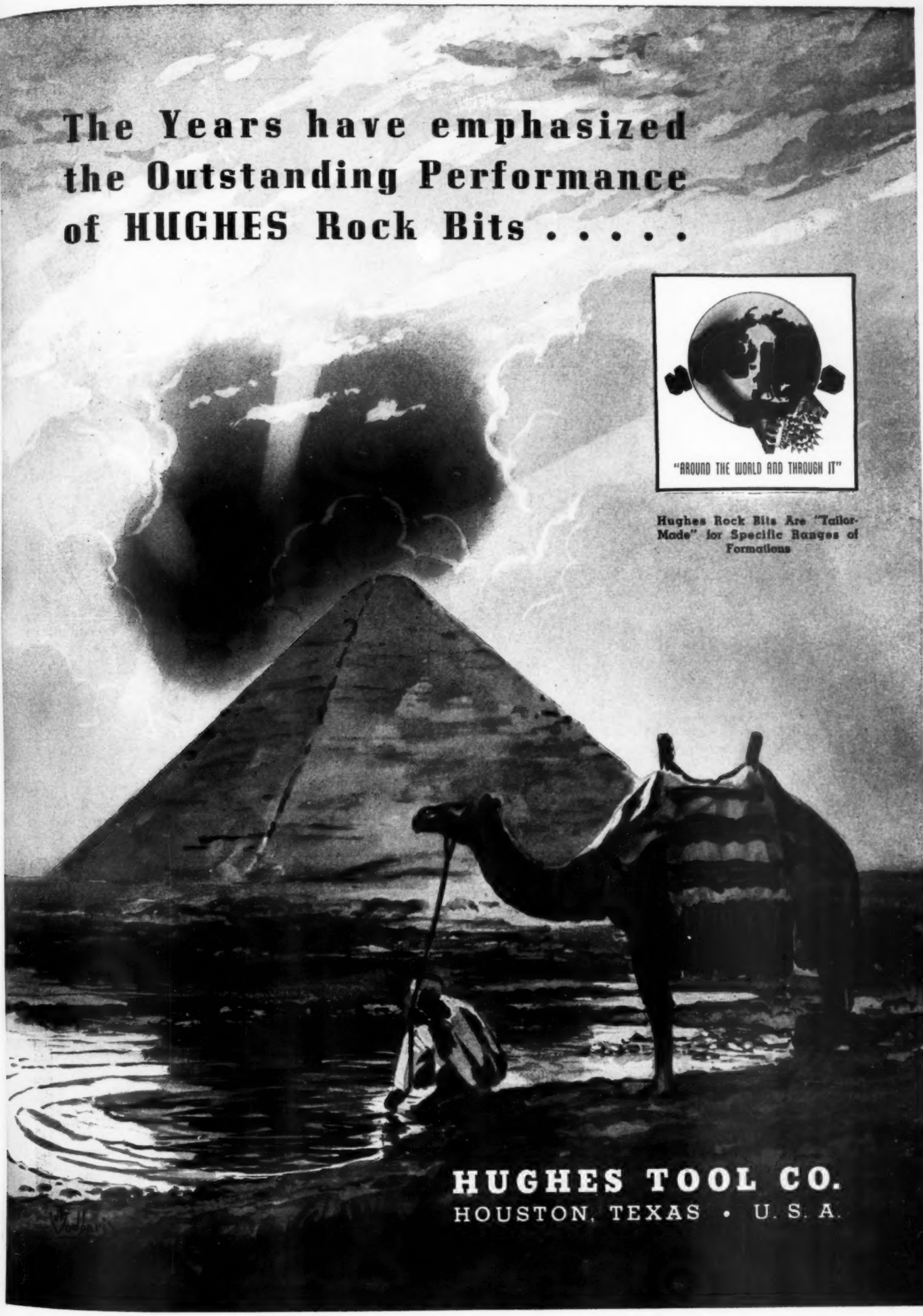
Liquids condensing after the compression are cooled to a temperature of about 90 deg. fahr. and pumped to the high-pressure accumulator, which also constitutes the stabilizer feed tank.



Feed tank for polymerization unit

The Years have emphasized the Outstanding Performance of HUGHES Rock Bits . . . . .

Hughes Rock Bits Are "Tailor-Made" for Specific Ranges of Formations



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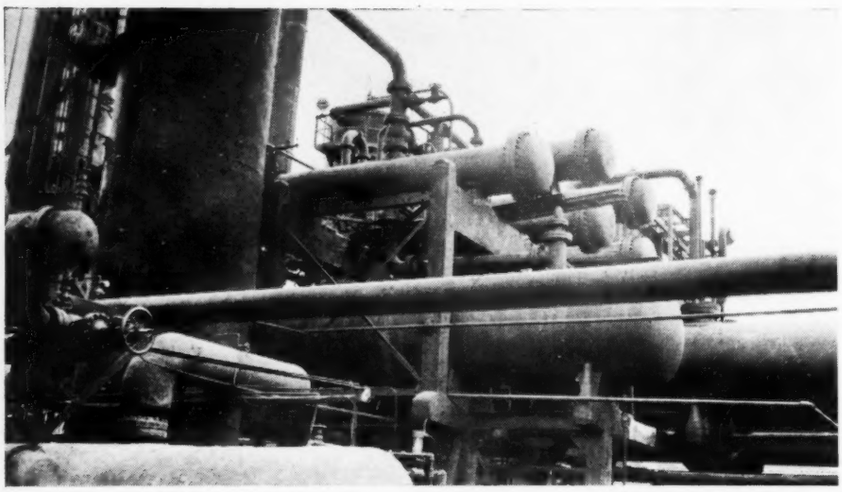


Banks of receivers and shell-and-tube condensers

Pressure on the stabilizer feed tank is maintained at 440 lb. gauge; the stabilizer column is operated at about 380 lb. gauge. The feed temperature is about 170 deg. fahr. when process material leaves the stabilizer feed heat exchanger, and about 270 deg. fahr. after the material flows through the stabilizer heat exchanger and preheater. The temperature of the reboiler of the stabilizer is maintained at about 425 deg. fahrenheit. A cut is taken from either or both of the Gyro cracking plant fractionating columns, and flows first through the pressure-distillate rerun fractionating column reboiler, and then through the stabilizer unit.

Reflux maintains the temperature of the stabilizer overhead vapor stream at about 170 deg. fahrenheit. The vapor stream is cooled to condense sufficient liquid to return to the overhead nozzle, temperature on the reflux liquid being maintained at about 140 deg. fahrenheit. Excess vapors and those not condensed in the stabilizer reflux condenser pass immediately to the secondary cooling equipment, where they are cooled to a temperature of about 90 deg. fahrenheit. Excess gas, both from stabilizer receiver and stabilizer feed tank, is released by automatic instruments and fed directly to the high-pressure absorber wherein valuable fractions not condensed in regular stabilizer operation are recovered.

Analysis of the wet gas to compressors is as follows:

Specific gravity	1.268
Percent unsaturates	45.4
Percent C_1 and C_2	54.41
Percent C_3	27.91
Percent C_4	11.22
Percent C_5	6.46
Total	100.00

Fractional analysis of the gas entering the high-pressure absorber, which is a combination of uncondensed vapors from the poly feed tank and the stabilizer feed tank, is as follows:

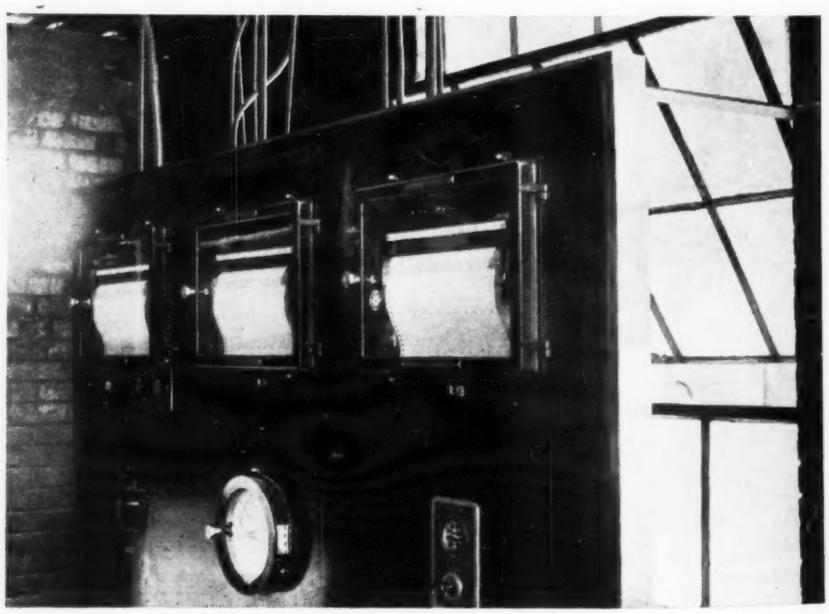
Specific gravity	0.612
Percent unsaturates	14.600
Percent C_1 and C_2	92.940
Percent C_3	7.060
Percent C_4	0.000
Percent C_5	0.000
Total	100.000

Liquefied products of the two-stage compression plant, condensed and accumulated in the polymerization plant feed tank, are subjected to a pressure of about 370 lb. gauge. The polymerization plant charge pump takes suction, through a flow controller, directly from the vessel and pumps the charge, without heat exchange, to the polymerization pyrolysis coil, or poly furnace. The inlet temperature is about 90 deg. fahr. and the outlet temperature is about 1000 deg. fahrenheit. The outlet pressure is about 540 lb., a tube travel drop in pressure of about 260 lb., as charge pump pressure is maintained at about 800 lb. gauge. Analysis of the material pumped to the pyrolysis coil or furnace is as follows:

Polymerization Charge

Specific gravity	1.425
Percent unsaturates	44.600
Percent C_1 and C_2	31.250
Percent C_3	50.920
Percent C_4	17.150
Percent C_5	00.680
Total	100.000

Process material leaving the pyrolysis coil enters the polymerization coil, or reactor, and flows through this equipment without appreciable drop in pressure. A number of tubes are incorporated in this unit. The temperature is maintained at or slightly above the inlet temperature by introducing poly arrestor liquid, usually a portion of the condensate formed in the condenser on the outlet of the reactor. On the outlet of the reactor, or polymerization coil, the piping forks into two sections carrying about equal portions of the product leaving the reactor. The point where the two sections join is called the arrestor. Temperature in the arrestor inlet, or just before quenching by arrestor liquid, is approximately the same as that in the outlet of the polymerization coil itself, but is reduced

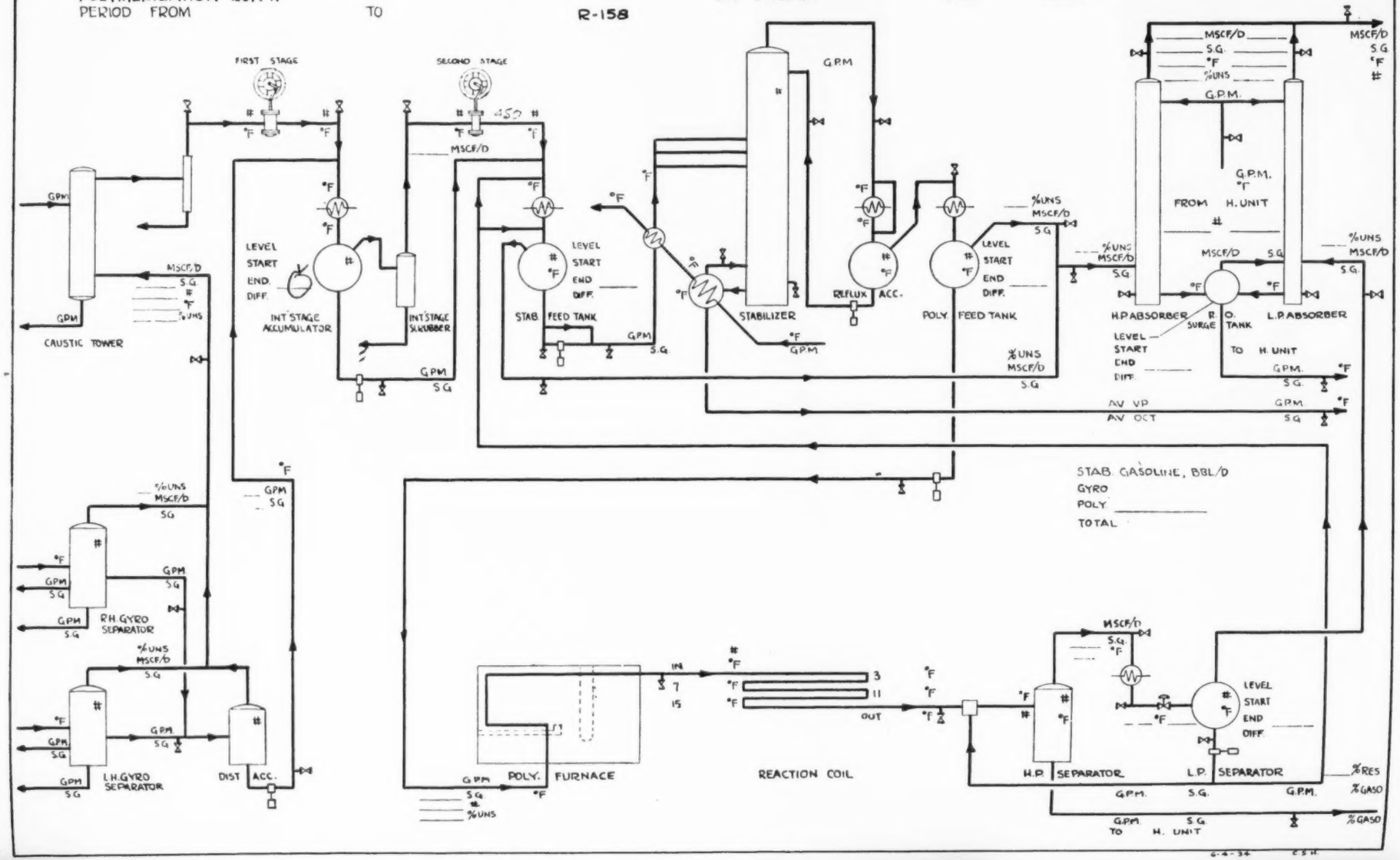


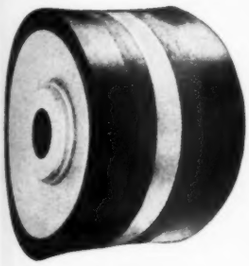
Furnace control panel

The new Schlumberger "Electrical Well Logging" catalog, No. 809, is ready. A copy will gladly be sent to interested persons on request. Schlumberger Well Surveying Corporation, Houston, Texas.

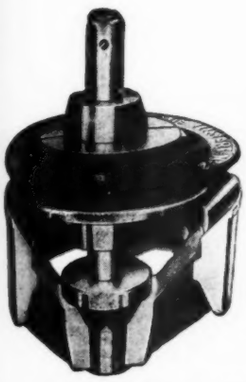
GAS & POLYMERIZATION UNITS REPORT

STABILIZER RUN Nº SHEET Nº ON STREAM HRS. MINS. 24HRS. ENDING 7 A.M.
POLYMERIZATION RUN Nº ON STREAM HRS. MINS.
PERIOD FROM TO R-158



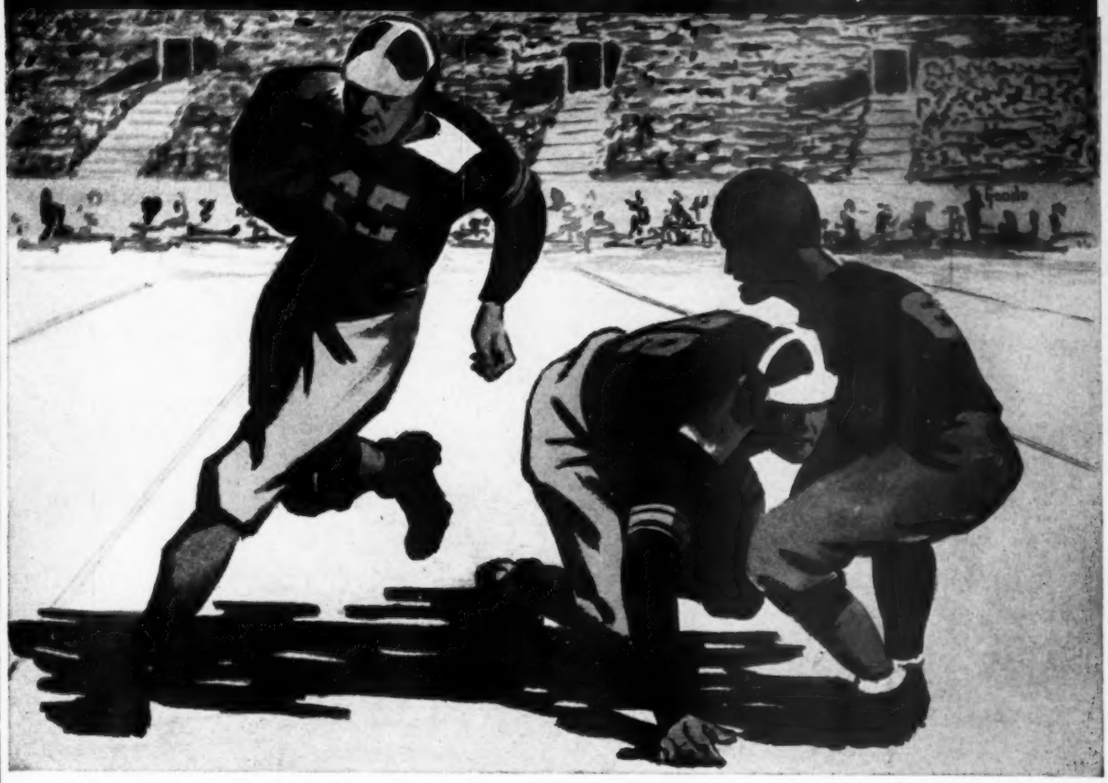


MISSION PISTON



MISSION SILVER TOP VALVE

SIDE-STEP..... COSTLY PUMP UPKEEP



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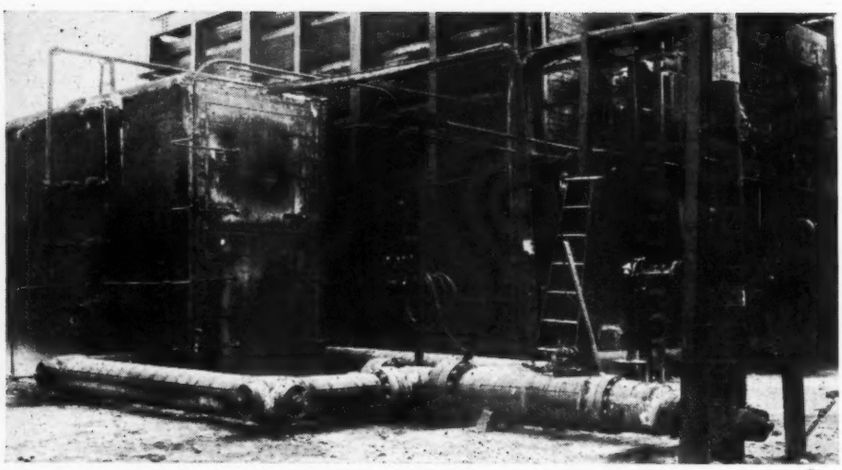


Outlet end of reactor coil

on the outlet to about 440 deg. fahr. by control of the arrestor pump discharge.

The first vessel, termed the high-pressure separator, receives all the material leaving the reactor coil. The pressure is maintained at about 500 lb. gauge, and the temperature at about 375 deg. fahrenheit. Gases or vapors enter a water-cooled condensor, wherein the temperature is reduced to about 85 deg. fahr. when vapors and liquid are released. Vapors pass to the low-pressure absorber and liquids are pumped to the stabilizer feed tank for fractionation and stabilization. All liquids entering the stabilizer are separated in two cuts; the first, from the base, is liquids of desirable Reid vapor pressure, the second is overhead, which is liquefied for poly feed. Thus a portion of the product obtained by cracking is recycled until reacted upon favorably by the polymerization plant.

Analyses of low-pressure separator gas and low-pressure bottoms are as follows:

	Low-pressure separator gas	*Low-pressure separator bottoms*
Specific gravity	1.132	----------
Percent unsaturates	21.400	----------
Percent C_1 and C_2	57.850	13.090
Percent C_3	35.220	45.970
Percent C_4	6.930	27.020
Percent C_5	Trace	13.920
Total	100.000	100.000

The absorbent is made in the refinery, and flows into the two columns in the volume required to absorb completely the desirable components of the gaseous feed. The high-pressure absorber is operated at a pressure of about 370 lb. and the low-pressure absorber at a pressure of about 205 pounds. Residue gas, in this plant termed power gas, from both absorbers is combined for use as plant fuel and for other purposes. Analysis of power gas is as follows:

Power Gas

Specific gravity	.898
Percent unsaturates	19.800
Percent C_1 and C_2	83.010
Percent C_3	16.980
Percent C_4	Trace
Percent C_5	None

All products liquefied in the polymerization plant are pumped to the Gyro distillate feed, or accumulator tank that is used as a surge vessel for rerunning the material produced. This liquid is pumped to the rerun tube furnace and subsequently fractionated, after being processed in clay chambers. Polymer bottoms from clay treatment are separated from the stream in the rerun fractionating column, cooled, and pumped back to Gyro cracking unit work tanks for inclusion with feed to those units. Overhead is condensed by flowing through the stabilizer vapor heat exchanger (feed to stabilizer against overhead vapors on rerun column) then through a condenser to the accumulator tank where uncondensed gas is separated from the liquid and returned to the compressors for reprocessing. Liquid from the base of the gas separator, or rerun column condenser accumulator, constitutes Gyro gasoline containing poly gasoline.

When the plant is operating at normal temperature, pressure, feed, and composition of gas to the compressors, the distillate from the rerun unit has the following analysis by Engler flask and ASTM method:

Gyro gasoline containing poly gasoline

Gravity	59.0 deg. A.P.I.
I. B. P.	86°F.
10%	130°F.
20%	156°F.
30%	192°F.
40%	222°F.
50%	256°F.
60%	286°F.
70%	314°F.
80%	350°F.
90%	380°F.
E. P.	407°F.
Recovery	95 percent
Residue in flask	1 percent
Distillation loss	4 percent
Reid vapor pressure	12.2 lb.
Octane number	72.3 C.F.R.

When the Gyro cracking units are operating, but polymerization is not included, the analysis of the gasoline is as follows:

Gyro gasoline containing no poly gasoline

Gravity	57.4 deg. A.P.I.
I. B. P.	89°F.
10%	148°F.
20%	182°F.
30%	216°F.
40%	246°F.
50%	274°F.
60%	300°F.
70%	318°F.
80%	348°F.
90%	378°F.
E. P.	409°F.
Recovery	95 percent
Residue in flask	1 percent
Distillation loss	4 percent
Reid vapor pressure	12.6 lb.
Color	21
Octane number	70.2 C.F.R.

As will be seen, the initial boiling point and final boiling point are approximately the same for both samples, but the 10% point differs by 18 deg. fahr., and the 40% point differs by 24 deg. fahr., and the octane number of the straight product is only 70.2, whereas that of the sample including poly gasoline is 72.3. Vapor pressure and color are virtually the same for both samples.

The High-Pressure High-Temperature Turbine Electric Steam Ship "J. W. Van Dyke"*

Part 1

By LESTER M. GOLDSMITH

Chief Engineer, The Atlantic Refining Company

FOR a better understanding of the engineering development leading up to the construction of the tanker S.S. "J. W. Van Dyke," an outline of some of the previous marine engineering experience of The Atlantic Refining Company will first be given and may serve as a clarifying background for a ship carrying the highest steam pressure and temperature ever to go to sea from the United States.

Twenty years ago this company pioneered in the installation of Alquist or laminated type of double reduction gears in five ships of 2600 s.hp. each, went through the entire period of this early development in reduction gears, and replaced them finally with compound turbines and single reduction sets having solid gear wheels and embodying low tooth pressures in the design.

Fifteen years ago the company again pioneered by designing and building the first three Diesel-electric tugs and a 1200-ton Diesel-electric tanker, immediately followed by a 7500-ton tanker with the same system of propulsion. These installations were followed by others until this company had a fleet of fourteen vessels with Diesel-electric machinery, ranging in size from approximately 400 to 3000 shaft horsepower. At the same time, it was also operating on the same routes a number of the older steam-powered ships having both reciprocating and geared turbine machinery.

In view of this pioneering, and the experience and engineering development which followed it, together with the fact that the owners were manufacturers of petroleum products, it is evident that the company's engineers were absolutely unbiased from an engineering viewpoint, and had no other goal or object than to produce power for propulsion and transportation at the least cost per s.hp. and per ton-mile.

By the year 1930, experience with, and observation of, Diesel-engine installations had convinced the company that this form of power had definite limitations. In other words, for horsepowers to 3000, the Diesel engine is an undeniably economical prime mover, but above that size, doubtful, especially in view of the advent of the high-pressure, high-temperature steam turbine. Having in mind that the company, within five years, would be faced with the necessity of replacing its then existing tonnage, the author inaugurated a study and thorough investigation of high-pressure and high-temperature steam plants. It was not until 1935, however, that the conclusion was reached that boilers and small turbines, using high-pressure and high-temperature steam, were suitable for marine application. Keeping in mind the background of experience outlined above, studies were made and

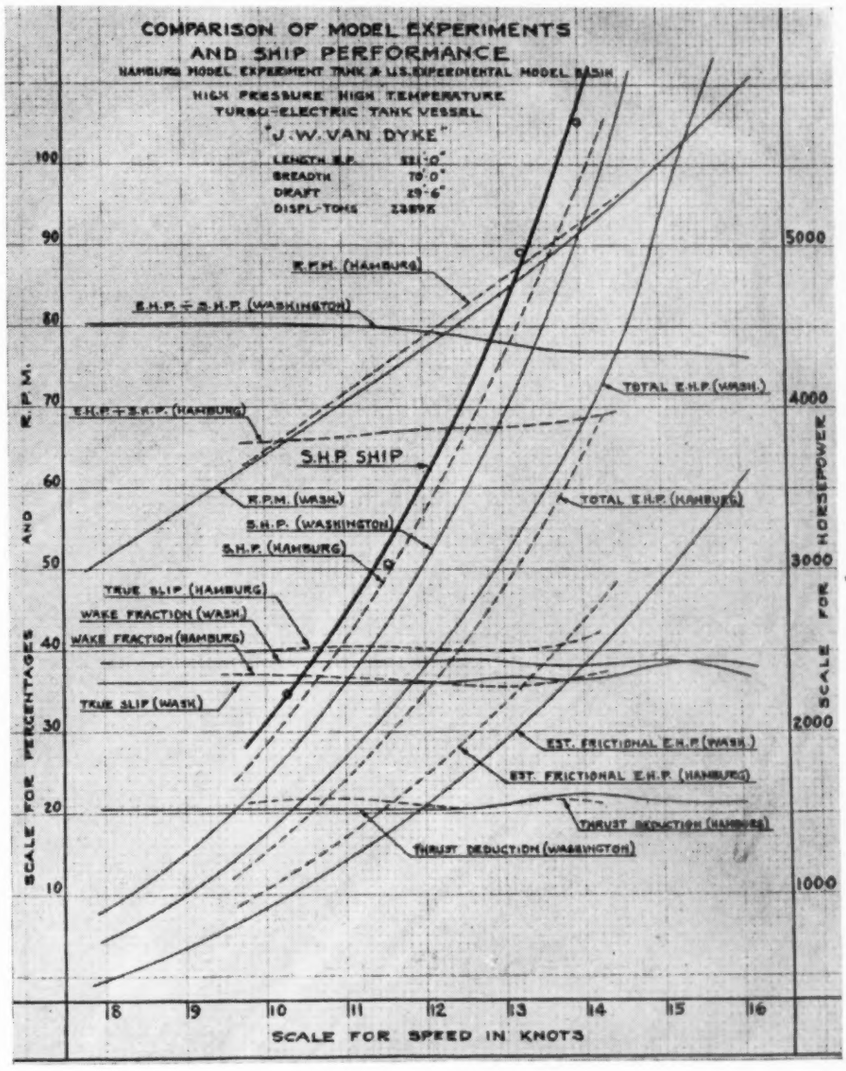
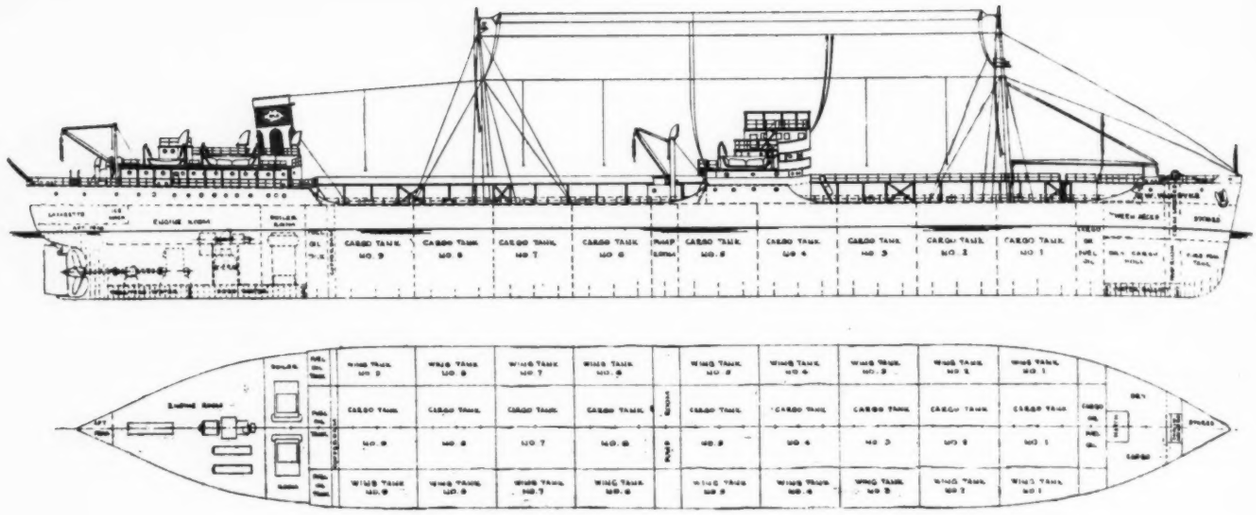


Fig. 1

*Paper to be read before American Society of Mechanical Engineers at the Annual Meeting in New York, December 5, 1938.



S.S.J.W. VAN DYKE

Fig. 2

tabulated of all available types of power plants, including Diesel-electric, direct Diesel, geared turbine, and turbo-electric.

While these data were being collected and analyzed, an intensive study of hull form and propeller design was begun. In order to correlate the power plant-propeller-hull studies, a description of the latter is first given.

The project was to design a modern tank vessel to carry approximately 18,000 tons dead weight on a length of about 520 ft. between perpendiculars and a maximum moulded draft of 29 ft. 6 in. at an average sea speed of 13¼ knots. This speed was considered the most profitable after a careful study of the conditions under which the ship was to run by the operating department, and is the point at which a further increase in speed would reduce the margin between operating cost and gross profit.

As the company's last three large Diesel-electric ships were built in Scotland, the first studies of the new hull design were made there.

A hull of the following dimensions was finally settled upon for tank testing and determination of propelling power:

Length (between perpendiculars)	520 ft. 0 in.
Breadth, moulded	70 ft. 0 in.
Draft, moulded	29 ft. 6 in.
Black coef. (On between-perpendiculars length)	.780
Displacement, tons	23,989

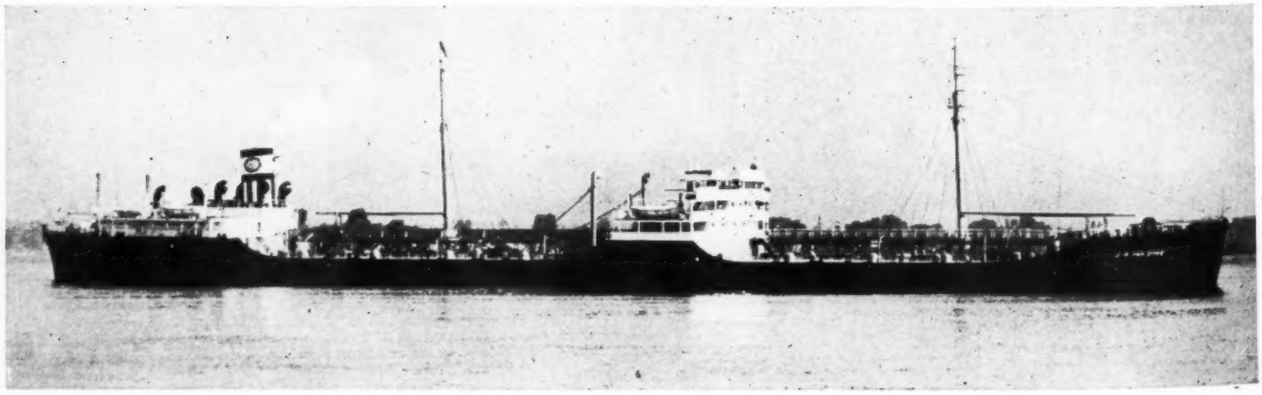
The Hamburg Model Experiment Tank was chosen for model tests, as it is well known to be the largest and best equipped institution of its kind in the world and work on the previous ships had been done there. At the time these experiments were started in March, 1934, there was still doubt in the minds of some shipbuilders as to the value of the so-called cruiser stern on the average commercial ship and in order to get conclusive evidence on this point, the model was towed both with cruiser stern and with what is now almost obsolete, the overhung

TABLE I

Speed in knots	*Effective hp., counter stern*	*Effective hp., cruiser stern*	*Improvement by use of cruiser stern, hp.*
10	1,298	1,242	56
11	1,742	1,676	66
12	2,292	2,213	79
13	2,944	2,852	92
14	3,756	3,625	131

NOTE: By effective horsepower is meant the horsepower determined by towing the model and therefore propulsion losses are not included.

Fig. 3



counter stern. The results given in Table 1 leave no doubt as to the value of the former in cutting down eddy-making and reducing the total resistance by an appreciable amount.

Self-propelled tests were next run with the cruiser stern model, using propellers designed by the Hamburg Model Basin staff. Two different propellers were tried. (Table 2.)

From this it can be seen that propeller 1275 gave the better results at the designed speed of 13.25 knots.

As stated, these tests were run in March, 1934, and it was not until January, 1936, that the company was ready to go ahead with the construction of the vessel. In view of this lapse of time and the fact that some higher propulsive efficiencies than shown in the Hamburg tests apparently had been obtained in one or two cases in this country, it was decided to have the same model experiments repeated at the U. S. Model Basin in Washington. This would serve not only as an interesting check on the results but would also provide opportunity for further possible improvement in efficiency. A model from the same lines was therefore tested at Washington at the same displacement, both for effective hp. and self-propelled for shaft hp. with a propeller designed by the Washington Model Basin staff. The results of these tests together with those obtained at Hamburg are shown in Fig. 1, and the principal characteristics of the two propellers are given in Table 3. From an inspection of the curves, it is readily apparent why the propeller developed in the U. S. Model Basin was adopted.

With regard to the structural plan

TABLE 3
Propeller Characteristics

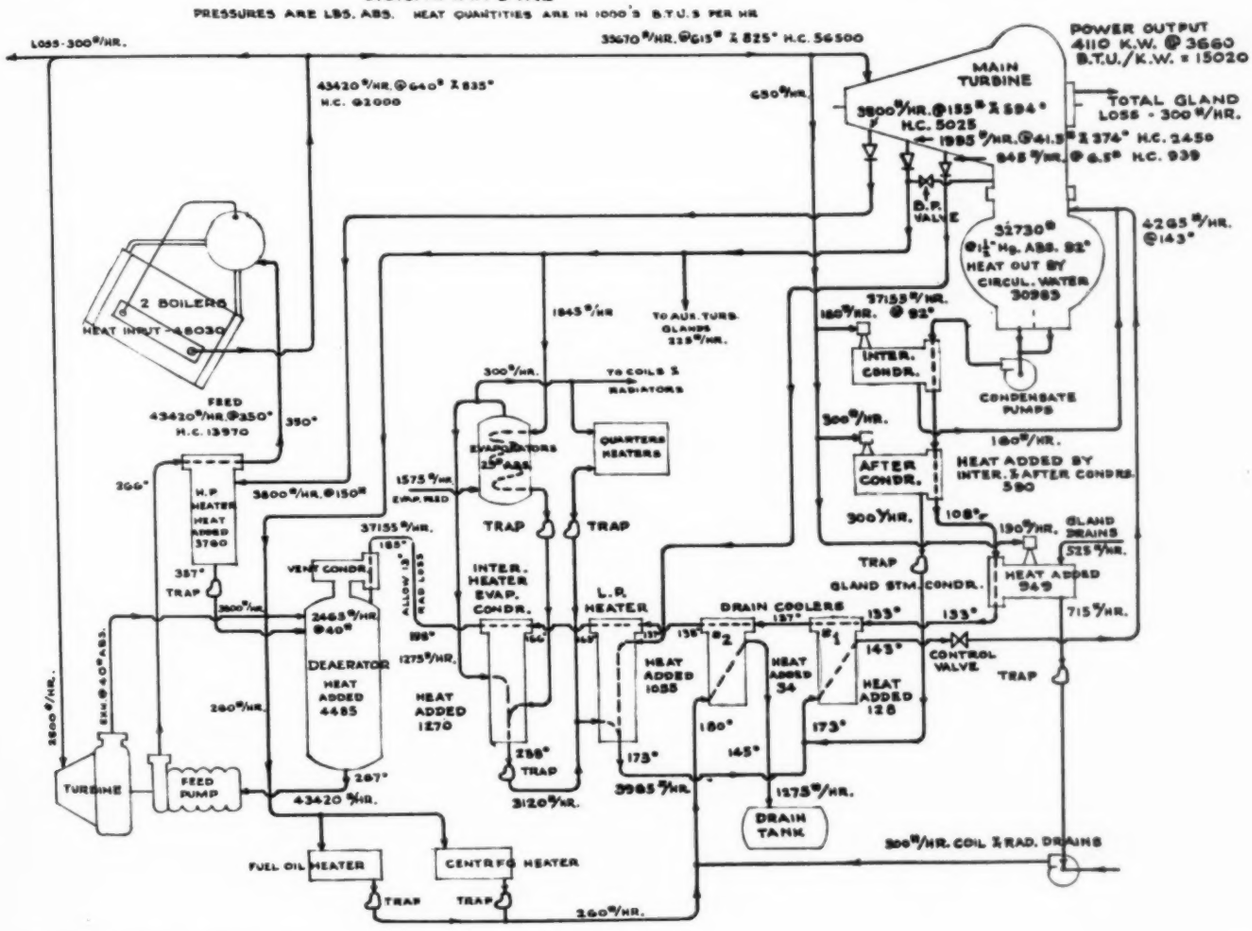
	Washington	*Hamburg*
Diameter, ft.	19.5	18.17
Effective pitch, ft.	15.167	16.54
Number of blades	4	4
Disc area, sq. ft.	298.6	259.5
Projected area, sq. ft.	118.0	
Developed area, sq. ft.	128.60	116.7
Pitch ratio	.778	.910
Developed area ratio	.431	.450
Projected area ratio	.395	

TABLE 2

Speed in knots	*E. hp.*	PROPELLER 1257 *S. hp.*	*Prop. coef.*	*R.P.M.*	PROPELLER 1275 *S. hp.*	*Prop. coef.*	*R.P.M.*
10	1,242	1,853	67.0	70.3	1,890	65.6	64.3
11	1,676	2,490	67.4	78.0	2,535	66.1	71.5
12	2,213	3,289	67.3	85.8	3,290	67.2	78.4
13	2,852	4,294	66.4	93.7	4,235	67.3	85.5
14	3,625	5,410	67.0	101.5	5,280	68.6	92.5

Horsepowers are metric. Multiply by 1.0138 to convert to English horsepower.

FIG. 4 HEAT BALANCE DIAGRAM
S.S.J.W. VAN DYKE



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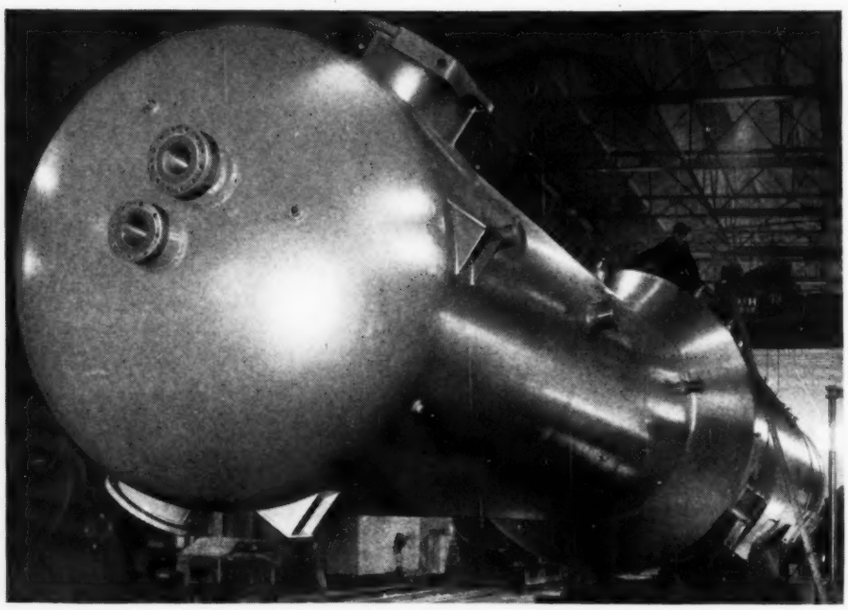

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TABLE · 5 SUMMARY OF MATERIAL AND HEAT BALANCE COMPARISONS

LOCATION	DESIGN CONDITIONS		#1 FUEL RUN · 4 HRS.		#2 FUEL RUN · 3 HRS.		J.W. VAN DYKE · 4 DAYS		J.W. VAN DYKE BEST DAY		ROBERT H. COLLEY 6 HOUR TEST RUN		DERIVATION OF QUANTITIES
	QUANTITY	HEAT (000 BTU/hr.)	QUANTITY	HEAT	QUANTITY	HEAT	QUANTITY	HEAT	QUANTITY	HEAT	QUANTITY	HEAT	NOTE - ALL INSTRUMENTS WERE CAREFULLY CALLIBRATED FOR THESE TESTS.
FEED WATER TO BOILERS	43420	13970	43625	14108	44023	14130	43700	14050	43300	14780	43920	14940	BY METERS
HEAT INPUT TO BOILERS	"	48030	"	48713	"	48960	"	50130	"	49800	"	50920	FROM INSTRUMENTS
TOTAL FROM BOILERS	"	62000	"	62813	"	63090	"	65100	"	64580	"	65900	" "
TO FEED PUMP TURBINES	2800	3996	2930	4260	2970	4260	2980	4250	2980	4260	3000	4290	CALCULATED FROM PUMP & TURBINE CURVES.
AIR JET VAC PUMPS	650	928	700	1010	700	1004	700	998	700	998	700	1002	FROM MANUFACTURER'S FIGURES
AUXILIARY SET	RUN AS MOTOR FROM MAIN GENERATOR												
UNACCOUNTED FOR LOSS	300	576	375	353	193	136	470	602	320	442	120	558	BY DIFFERENCE
TO MAIN TURBINE	39670	56500	39600	57200	40180	57700	41350	59250	41300	58900	39300	56900	BY METER
FROM #1 BLEED	3600	5025	3530	4750	3720	4980	4300	5770	4170	5600	3560	4810	CALCULATED FROM TEMPERATURE RISE IN H. HEATER
#2 BLEED	1995	2450	1820	2200	1844	2250	1232	1490	1390	1697	1835	2240	CALCULATED FROM TEMP. RISE IN INTER. HTR. & DEAERATOR
#3 BLEED	845	939	0	0	0	0	0	0	0	0	0	0	
GLAND LOSSES ETC.	300	336	300	336	300	336	300	336	300	336	300	336	MANUFACTURER'S FIGURE
TO CONDENSER	32730	32730	35950	35614	34316	35934	35726	36634	35440	36467	34000	35054	BY DIFFERENCE.
TO POWER		15020		14280		14200		14820		14920		14460	FROM MFGR'S FIGURE OF 3660 BTU (534% MECH EFF.) PER K.W.H.
SHAFT HORSEPOWER	5000		4980		4940		5080		5080		NO METER FITTED		BY TORSION DYNAMOMETER
LBS. TOTAL STEAM/S.H.P.HR.	8.68		8.76		8.95		8.99		8.92				
% HEAT FROM FUEL TO SHAFT	22.3		22.0		22.4		22.7		22.7				
LBS. TOTAL FUEL/S.H.P.HR.	.596		.594		.598		.592		5.91				NOTE-THIS IS TOTAL FUEL FOR ALL PURPOSES AND AUXILIARIES HEAT VALUE OF FUEL = 19000 B.T.U./LB.
% FUEL FOR AUXILIARIES	14.4		15.5		15.4		15.7		13.9				
LBS. FUEL/S.H.P.HR. (FOR PROPULSION ONLY)	.510		.502		.508		.511		.512				

of the vessel, the chief point of interest is the fact that her entire cargo tank and fuel bunker space, comprising a length of 353 ft., is electrically welded throughout. The bow and stern portions of the ship were riveted in the orthodox manner. The general arrangement otherwise follows more or less usual tanker practice. The ship is a poop, bridge, and forecastle type with one continuous deck and two longitudinal bulkheads and sixteen transverse bulkheads, the cargo space consisting of nine 3-compartment tanks with a total capacity of 868,980 cu. ft. or 6,500,000 gallons. The modern tendency toward streamlining is followed to a moderate extent by rounding the fronts of bridge structure and poop and by giving the stack an ogival section. A general arrangements and profile plan of the ship are shown in Fig. 2, and her general appearance in Fig. 3.

Power Plant

After all the analytical work was finally reduced to figures, it was disclosed that it would require 5000 hp. to propel this vessel at the desired speed, as indicated by the model basin work shown on Fig. 1. It was decided that for this horsepower, the form of power promising the lowest overall operating cost per s.hp. was the turbine-electric drive. The reasons for selecting the turbine-electric drive embody more than just propulsion, for it was the request of the management that this vessel be outstanding in its ability to discharge cargo rapidly. In order to meet the requirements for discharging in less than 12 hours, pumps having a rated total capacity of 10,500 gal. per min. at the desired pressure were selected. It was found that approximately 1000 hp. would be required for these pumps when discharging in port. In addition, the trim of the vessel necessitated location of this cargo-pump room amidship. It can be seen, therefore, how simple it is to obtain this power from a standard turbine generator and operate the pump electrically. It must also be kept in mind that not only economy of operation, but first cost and reduction of weight should be in the mind of every designer of any transportation equipment.

To meet existing rules of the American Bureau of Shipping, the Bureau of Marine Inspection and Navigation, and the requirements of economy in general, it was decided that the turbine should be designed for 600-lb. pressure, 825-deg. fahr. steam. When the decision was made to go to this high pressure and temperature, one problem eliminated by the use of motor instead of gear drive was the problem of the reversing turbine, and the question of keeping it cool.

In the tabulation of the engineering design of the previous turbine-electrically propelled vessels, both in this country and abroad, it was disclosed that none utilized a generator of standard voltage and frequency as we know them to be standard, thinking of land power plants in this country, nor did they employ the use of alternating current for auxiliary uses as all land

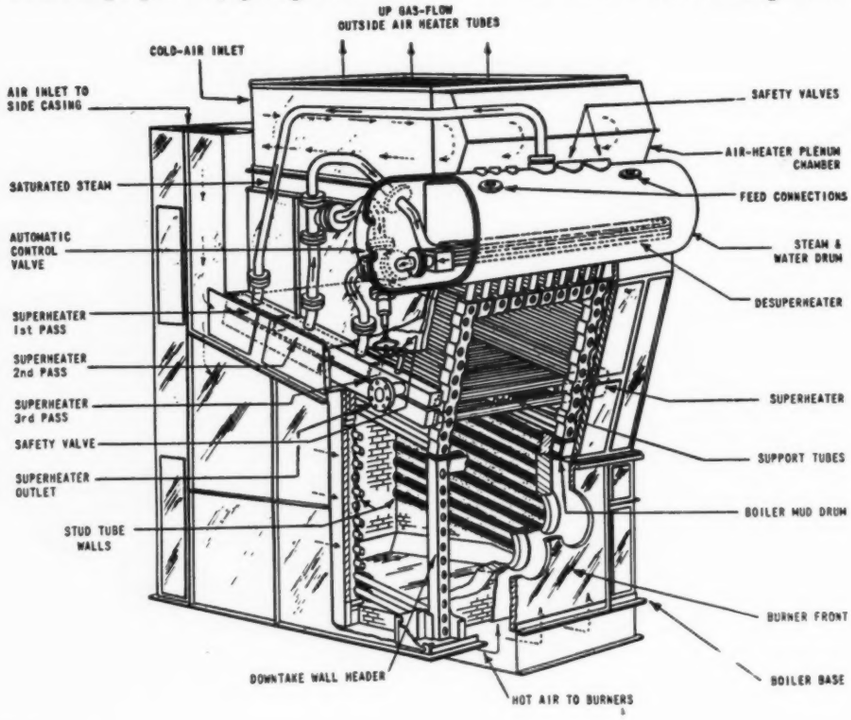
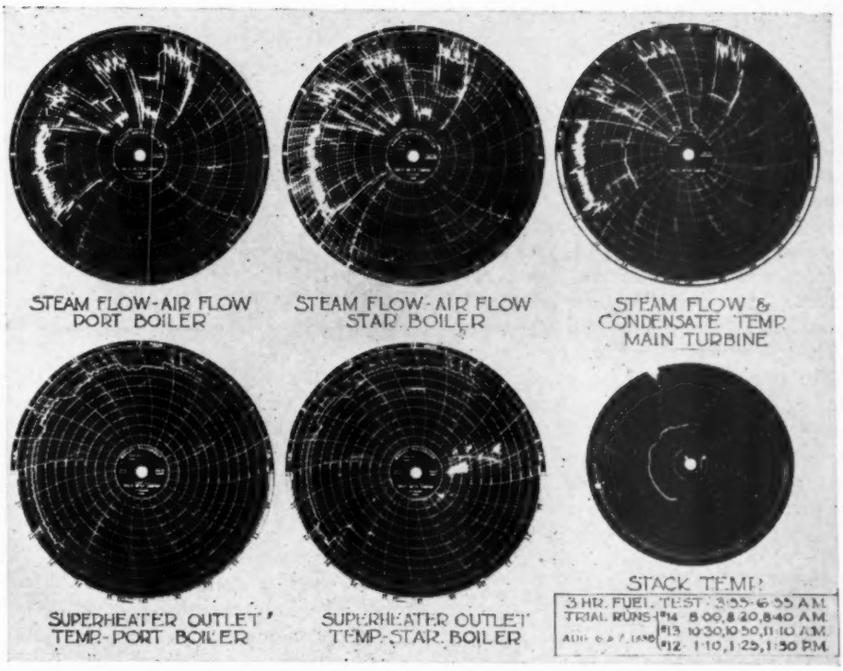


Fig. 6

Fig. 7


STEAM FLOW-AIR FLOW PORT BOILER
STEAM FLOW-AIR FLOW STAR. BOILER
STEAM FLOW & CONDENSATE TEMP MAIN TURBINE
SUPERHEATER OUTLET TEMP-PORT BOILER
SUPERHEATER OUTLET TEMP-STAR. BOILER
STACK TEMP.
3 HR. FUEL TEST 3:55-6:55 A.M.
TRIAL RUNS #14 8:00,8:20,8:40 A.M.
#13 10:30,10:50,11:10 A.M.
#12 1:10,1:25,1:50 P.M.

plants do. As no reason could be found why other than standard equipment should be used, engineering work was started with the idea of profiting by the principles in use in every modern land power station. A complete heat balance, as shown on Fig. 4, was first worked out in connection with the machinery manufacturers.

Three bleed stages were decided upon as giving the best compromise between the ideal and the practical complications of space requirements and piping. Another consideration borne in mind was that evaporation of feed water should be reduced to a minimum and that every possible precaution must be taken to protect the boilers from impure water; therefore, all clean drains are collected and returned through a cooler into the main condenser but drains that are subject to possible contamination are re-evaporated. The evaporators are planned to float on the line and normally only one of them, operating at much below its rated capacity, will be required. Under sea conditions, the heat of the evaporator vapor is used to supply such low-pressure steam as may be required for general heating purposes throughout the ship, and the remainder goes to the intermediate feedwater heater so that this heat is recovered. An emergency vapor line to the condensers is also provided for port use, but with proper operation, this should not normally be necessary.

All three boiler feed pumps are turbine driven. Only one is required for normal operation. The exhaust is added to the second stage bleed.

It will therefore be noted that under normal conditions the heat from the evaporator vapor and the feed pump exhaust is either recovered in the feed or otherwise usefully employed.

No heat that can be put to use is rejected to the sea water except under unusual conditions.

Fig. 5 gives a comparison of the heat distribution as planned and as actually obtained. It will be noted that an overall heat efficiency from burners to shaft of 22.5 percent was expected. During the trials, we obtained efficiencies as high as 22.6 percent and in actual operation have obtained 22.7 percent. It should be noted that these figures are that portion of the total heat supplied by the fuel to the burners which is used for propulsion and not the gross steam cycle efficiencies, which figures are 26.4, 26.1, and 26.0 percent respectively.

The auxiliary sets do not enter into the normal heat balance picture as under usual load conditions they are electrically driven from the main generator.

Steam Generation

The design of the steam generation plant is as follows:

Boilers are of the single-pass straight-tube header type as shown in Fig. 6, embodying four decks of superheat, stud tube side walls, and air preheater.

Header type boilers with air heaters, but without economizers, were selected with the thought in mind that the extreme simplicity of this design would be reflected in maintenance cost and, in particular, that with this type of boiler, tubes can be plugged-off or even renewed without loss of ship time waiting for the boiler to cool enough so that the drums can be entered.

It will be noted that the arrangement is further simplified by the fact that the boilers are so designed that the gases rise straight through, no baffles being required, thus further reducing internal maintenance.

The boilers have a rated capacity of 22,500 lb. per hr. each, at 625 lb. gauge and 835 deg. F.T.T., with feed water at 300 degrees. They each have a total water heating surface of 3222 sq. ft., superheating surface of 1094 sq. ft., and air heating surface of 2412 sq. feet. The furnace volume is 426 cu. ft. per boiler, giving a liberation rate of 66,000 B.t.u. per hr. per cu.. foot.

The lower two rows of tubes in each half of the superheater are of 9 percent chromium alloy and the boilers can be safely operated at 900 deg. final temperature.

They are fitted with automatic air puff soot blowers.

The boilers are provided with complete automatic combustion control, including automatic superheat control, and the charts (Figs. 7 and 8) show show how well this equipment functions. The charts on Fig. 7 are from one of the trial runs and show a continuous record of a three-hour fuel test at constant load followed by three sets of runs at approximately full load, but under different ballast conditions. Note that no attempt was made to protect the boilers by gradual slowing or speeding of the main turbine, but in spite of this, the superheat temperature falls instead of rising when the load is dropped, and is held at the set temperature when load is applied. At low loads the boilers are on hand operation, hence the spread between the "air flow" and "steam flow" records.

If the low load condition is to be maintained for any length of time, the burners can be changed to suit and the system again put on automatic operation.

The arrangement of the superheaters and their control is interesting. The superheater is divided into two sections, and a desuperheating coil is located in the drum, which is so baffled that the entering feed passes along this coil. The saturated steam from the drum passes through the first half of the superheater and then is divided by a three-way valve so that a variable portion goes through the desuperheating coil before passing to the second half of the superheater. The three-way

valve is automatically controlled by the temperature at the superheater outlet.

It is interesting to note from precedent in this respect that today a land installation of a steam generating plant not embodying some form of automatic combustion control would be unthought-of. Yet in land plants, technical men, usually in the operating force and always in the supervisory force, are immediately available, whereas in the marine field, the supervision is only obtained at long distance. The successful operation of this type of equipment, as demonstrated on the SS "J. W. Van Dyke," will undoubtedly mean much greater application because of this demonstration. How well this control functions under sea conditions is shown by the charts on Fig. 8.

High Pressure Piping

In the design of the high-pressure steam piping, the rules of the Bureau of Marine Inspection, which, at that time, not only prohibited welding, but were written without provisions for temperatures above 750 deg., were somewhat of a handicap. However, through the coöperation of the Bureau, rulings were obtained that permitted using welded joints, stress relieved. The main steam connections to the boilers, the boiler header, and the line to the main turbine are of 5-in. I.D. by 6½-in. O.D. seamless .5-"Moly," .20-carbon steel tubing. This is heavier than necessary on account of the Bureau rules for thickness, which did not permit taking full advantage of the greater strength of "Moly" tubing at high temperatures. In order to reduce radiation loss as well as the number of joints, the equipment was arranged to reduce the high-pressure steam piping to a minimum and the total length of main steam lines, including expansion bends and valves, is as follows:

5-in. Header and main turbine connection	72 ft.
3-in. Butterworth heater connection	21 ft.
2½-in. Boiler feed pump main	22 ft.
2-in. Auxiliary generator connections	32 ft.

All the high-pressure steam piping is Carbon-"Moly," all flanges are recessed or tongue-and-grooved to give confined gaskets.

All bolts, including those in the feed discharge lines, are high tensile Class C.

Main Turbine Generator

This is rated at 4500 kw., 60 cycles, 2300 volts at 3600 r.p.m. when supplied with steam at the throttle at 600 lb. gauge and 825 deg. fahr. total temperature with exhaust at 28.5-in. vacuum.

The normal output for 500 s.hp. was expected to be 4200 kw., 3850 kw. going to the motor and 350 to auxiliaries.

The turbine is of the impulse type, having 15 stages with bleeds after the 3rd, 7th, and 12th stages. The rotor is a solid forging with the wheels integral with the shaft, the first wheel carrying a double row of blades and all the remaining wheels single rows. The case consists of an alloy fabricated steel high-pressure section and a cast-iron low-pressure section, the division occuring between the 10th and 11th stages. The case is also horizontally split to permit removal of the rotor. The blading of both wheels and diaphragms is cast iron or steel, depending on the temperature. The packings are of the labyrinth type, and the glands are steam sealed and provided with an automatic steam regulator.

Governing is accomplished by a valve chest containing six valves leading to the nozzle plate and so arranged that the nozzles are successively cut in or out as the turbine demand increases or falls, thus avoiding the loss that would be caused by throttling the supply. The speed range obtainable is 900 to 3780 r.p.m. corresponding to 22.5 to 94.5 r.p.m. of the propeller.

The generator, which is directly connected to the turbine, is of the rotating field type. The stator consists of six coils Y-connected and brought out to six terminals. The rotor is ventilated by integrally mounted fans, which force air into its ends and out at the center, then down through the air cooler, which is in turn water-cooled. This cooler is mounted directly under the generator and is housed in the same case. The bearings are of the plain babbitted type.

The combined turbo-generator set is only 22 ft. 9 in. long by 10 ft. 3 in. wide.

Editor's Note—This article will be concluded in the next issue of *The Petroleum Engineer*.

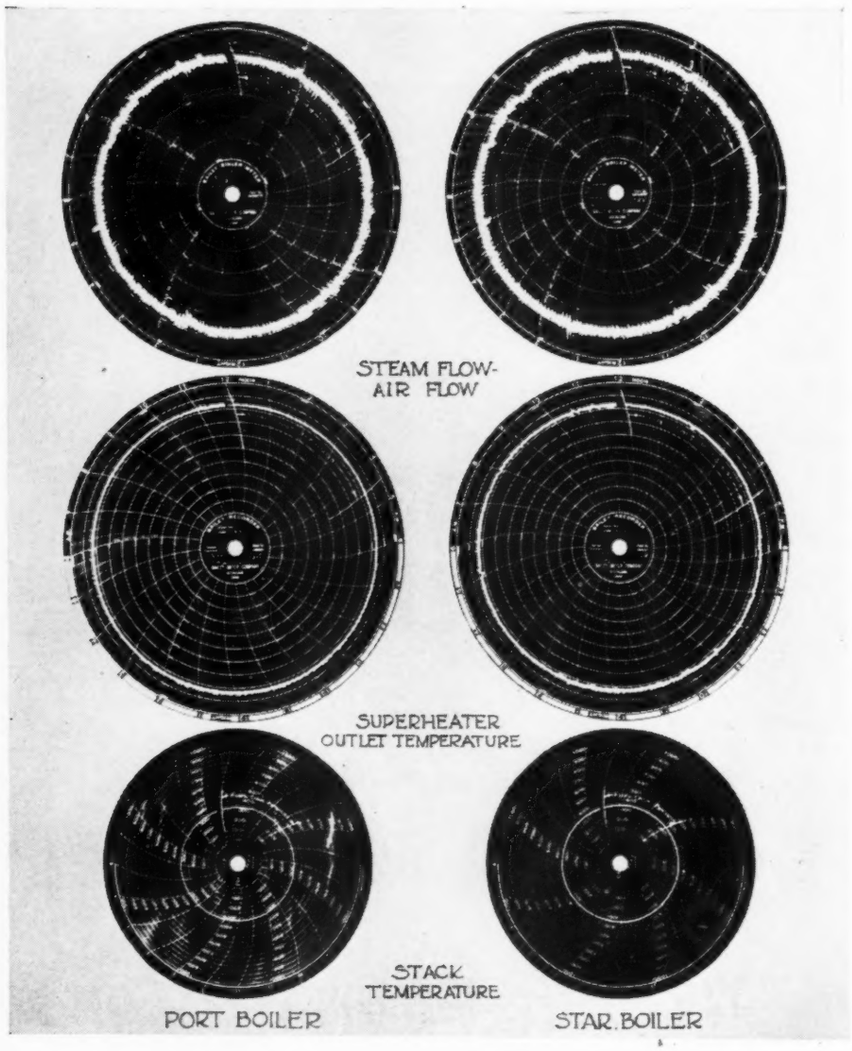


Fig. 8. Bailey Meter Company charts showing boiler operation under normal sea conditions

MOTIVES

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Profit is the motive of the vendor, but profit can have benevolent angles. The wise vendor endeavors to fill many real needs. He builds on a strong foundation of service to support the structure of his plans. He may sacrifice local or immediate profit for general or eventual gain. He makes an economic science of distribution, strengthening his ramifications as he goes. He seeks to earn a reputation for responsibility and fairness and permanence, for these things are more valuable than inventories and are not quickly or easily acquired.

Buying may also be constructive. In the oil business the effects are seldom limited to the satisfaction of an immediate need. Buying can heed future needs and encourage a character of service that will be of immeasurable benefit to the buyer. It can further the likelihood of repair parts service after flush production days. It can lay the weight of its influence on the side of quality and honesty and dependability.

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Abstracts of A. P. I. Papers, 19th Annual Meeting . . . Chicago . . . November, 1938

The Use of Rust-Hole Records to Study Pipe Service[1]

WALTER F. ROGERS*

THE Houston Pipe Line Division of the Gulf Refining Company has approximately 4000 miles of pipe line ranging in diameter from 4 in. to 12 inches. With but few exceptions this system consists of pipe laid without any coating to protect the metal from soil attack. The ages of these lines vary widely. Some new pipe mileage has been added almost every year since 1903.

These factors make the corrosion experience of these lines an excellent material source from which to study the problem of soil corrosion.

It has been found that if the cumulative rust holes are plotted against the time of burial in years on log-log paper, the resulting curve consists of one or several broken straight lines. In many cases it is possible to extrapolate a corrosion-history curve for at least two years, enabling a determination to be made two years ahead of time of the number of rust holes that will occur to that line. These curves may be used to determine pitting rates of soils as a whole. This has led to a determination of the value of pipe-wall thickness in effecting rust-hole occurrence.

Although these rust-hole-time curves plot straight lines on log-log paper, and in general are similar, each individual line has its own peculiarities.

As a general average, a line will have one to three slopes during 30 years of service. The first slope will vary between 2.0 and 12.5, but the most-likely value will lie between 3.3 and 12. During this time an average of 31 rust holes will occur. The second slope will vary between 3.3 and 1.4, and 46 rust holes will occur. The third slope either will revert to the high figure of 3.3 to 8.2, or will be less than 1.4—with the latter figure the more probable. During this time an average of 28 rust holes will develop. Most of the lines are still on their second or third slopes, so that the limiting number of rust holes for these cases will be somewhat greater than the figures given. These are, in general, the essential features of the rust-hole-time curves for pipe lines.

It was found, as a general average, that a rust hole on 6-in. pipe cost $71 in direct expense, and a total of 33.5 ft. of pipe was in such condition as to require in repairs the equivalent of replacing. It was found, for 8-in. pipe, that the total direct expense for a rust hole averaged $168, and a total of 40.9 ft. of pipe required the equivalent of replacing. These costs are probably subject to wide fluctuation among different companies, and such variation may be the basis for differences in repair methods used by them.

There are two general policies which may be followed in the maintenance of a pipe line: One is the long-line method; the other, "hot-spot" reconditioning. The exponents of the long-line reconditioning policy are those who, after a few rust holes appear through the line, are afraid that the entire line is in bad condition and must be taken up — otherwise repair costs will become excessive. This is the same as thinking that the high initial slope of the rust-hole-time curve will continue indefinitely. The exponents of the short-line reconditioning policy believe that money can be saved by repairing the rust holes as they appear, realizing that the high initial rust-hole-time slope will decrease with time.

As an example of the lower cost of short-line reconditioning, the total number of rust holes which has been repaired by this method in maintaining several hundred miles of pipe over a long period of time has been obtained. From these data, curves have been plotted to show the rust-hole-time relationship for 282 miles of 10-in. line having an average age of 11 years, 287 miles of 8-in. line having an average age of 26 years, and 169 miles of 6-in. line having an average age of 22 years. The 6-in. and 8-in. lines have, without exception, been kept repaired through the short-line reconditioning method. For the 6-in. lines at 22 years of age a total of 617 rust holes has been repaired. At $83 per rust hole, a total of $51,200 has been spent on these 169 miles. This is a total of only $330 per pipe-line mile. This is an insufficient amount to have allowed at any one time the entire number of miles to be taken up and inspected. The 8-in. pipe has an average age of 26 years. During this time 869 rust holes have occurred. At an average cost of $180 per rust hole, a total of $156,000 has been spent on maintaining these lines. This is a total of $540 per mile, which is likewise an insufficient amount to have taken up the entire line for inspection at any one time. The curve for the 282 miles of 10-in. line has a slope very similar to that of the 6-in. and 8-in. lines, and the curve is approaching the same values for rust holes vs. time as given by two smaller-diameter pipes.

In view of increased pipe strengths, it is only natural that the oil pipe-line industry would want to take advantage of the lesser-weight pipe that can be used, the purchase of which will result in considerable money saving. The industry has been somewhat reluctant to accept wholeheartedly the use of this lighter-weight and thinner-wall pipe because of the fear that rust-hole penetration would become so severe as to offset the initial saving. Furthermore, experience has shown that many coatings do not protect the pipe sufficiently to be of any value. During the last several years developments have occurred that act to enable pipe-line companies to take advantage of the lighter-weight pipe. One of these is the development of cathodic protection as a means of combining with a coating the ability to stop soil corrosion in its entirety.

The rust-hole data that have been accumulated have led to a determination of the value of wall thickness in affecting the rate of rust-hole penetration.

The light-weight pipe can be bought at a saving of $1,477 per mile. The added number of rust holes per mile experienced in 20 years by the 180-mil pipe are 3.37. At a rust-hole cost of $83 each, the added rust-hole cost in 20 years is $280. This still leaves a saving of $1,197 per mile. If it is desired to eliminate all rust holes, a high-resistance coating with a wrapper can be applied; and later, when the first rust hole appears, cathodic protection can be put on the line. The cost for the coating is $700 per mile. The cost

*Gulf Oil Corporation, Houston, Texas.

[1]Abstract of paper presented at nineteenth annual meeting, American Petroleum Institute, Chicago, November 18, 1938.

Cup Assembly Is Quickly Removed by merely unscrewing retaining nut at bottom of swab. Many operators, instead of using wrench, at top, insert a bar in fluid by-pass openings.

BELOW. Guiberson Type K Tubing Swab at Kansas well. In center is Bob Garden of R. E. Garden & Son. Guiberson will pay $5 to first person sending names of unidentified men in photo.

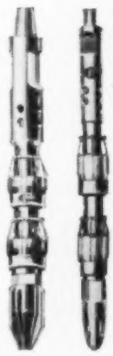
Ready to Run in, on the Illinois well shown at left, with 4-inch Guiberson Type K Swab. Jim Sloan, at right, is a driller of long experience, in West Virginia, Oklahoma, and, now, in Illinois, where this picture was taken, near Centralia. At left is Fred Rice, tooldresser. "The Type K is the best swab I've ever used; its flexible cups never stick going in or hang coming out, and it runs in at maximum speed," says Sloan.

"A FULL LOAD EVERY TRIP—AND TROUBLE PROOF," SAYS JIM SLOAN

JIM SLOAN—driller for a major company in Illinois—has been using Guiberson Swabs for many years. He tells us that he prefers the Guiberson (1) because it raises a full load, the cups expanding and contracting to make up for variations in pipe diameter; (2) because he finds it trouble-proof, as its flexible cups never stick; (3) because Guiberson, since they first brought it out, have continued to improve it. "The Type K is the best swab I've ever used," he says.

Bob Garden, shown at left, is another user and chooser of Guiberson Swabs.

Guiberson Swabs today do more than 90% of the world's swabbing because (1) they raise a full load, fluid pressure working with the cups to assure tight contact; (2) flexible cups won't stick; (3) running in, fluid and gas easily by-pass cups; (4) cups have maximum life due to oil-resistant composition, flexibility, protection of steel wires, and patented feature of molding cup around steel insert; (5) cups expand to fit pipe, after becoming worn.



Type "K" Casing and Tubing Swabs —Patented

See Composite Catalog, page 790. The Guiberson Corporation, Dallas, Texas. Export: I. Frank Brown, 30 Rockefeller Plaza, New York. California: W. R. Guiberson Co., 723 E. Gage Ave., Los Angeles.

for cathodic protection will be approximately $150 per mile. The addition of these costs still leaves a saving of $620 per pipe-line mile and rust-hole-free service. Actually, if cathodic protection is not put on until the fifth year after the line has been laid, the interest on the pipe saving during this five years is sufficient to pay for the cost of the cathodic protection.

From these data it is seen that light-wall pipe can be laid bare and maintained with an economic saving over laying heavy-weight pipe bare. In addition, light-weight pipe can be laid coated, and can have cathodic protection installed upon it to eliminate all rust-hole failures at a much less cost than installing heavy-weight pipe bare, but which will suffer rust holes. The use of heavy-weight pipe does reduce the number of rust holes, but not in sufficient quantities to pay for the added cost of pipe material. Continued calculations of this type show for a pressure of 700 lb. per sq. in. that, when the pipe diameter reaches 14 in., the wall thickness to stand this pressure is so great that the pipe cannot be referred to as thin-wall, and it becomes questionable whether the entire length of line should be coated when laid.

The Care and Maintenance of Instruments Used on Drilling Rigs[1]

E. L. DECKER* and N. L. DORN†

WITH the growing use of instruments there has arisen the problem of maintaining and caring for them under the rough conditions imposed by oil-field work. One of the main difficulties seems to be that the average crew fails to grasp the essential difference between a tool and an instrument.

Instrument makers have built an unusual ruggedness into the various measuring devices used in the oil fields, but the fact remains that instruments inherently are delicate. They must be to have the necessary sensitivity.

The reconciliation of these two opposites—the heavy-handed oil worker on the one side, and delicate mechanisms on the other — falls into two main problems: 1, the care and maintenance of those instruments owned by the operator, such as weight indicators, tachometers, slush-pump gauges, torque indicators, and mud-testing equipment; and, 2, the care of those instruments leased by the operator, such as survey outfits.

Leased Instruments

The first instruments used to determine the inclination of the bore hole were of the acid-bottle and of the go-devil-operated-plumb-bob-punch types. These instruments are often owned by the oil company.

The need for knowing the position of the bottom of the hole at all times was responsible for the development of the single-shot instrument, which gives both inclination and direction. These instruments are of such sensitivity and delicacy of construction that they are placed in service on a rental basis.

When a survey instrument complete with outer case and all necessary supplies is delivered to the rig, complete instructions as to operating the instrument, reading the record, and caring for the equipment are given by one of the service company's engineers. It is customary for periodic visits to be made to users of the service in order to check the equipment and replenish supplies. At the end of each job the equipment is inspected thoroughly in an instrument shop, and parts showing wear or damage are replaced. The manufacturer's service department is available continually to keep the equipment in good working order. If reasonable care is exercised by the men on the derrick, perfect results may be obtained from these instruments. The periodic check-up by the service engineer is sufficient to take care of ordinary wear and normal usage.

It has been found that the average oil worker's conception of careful handling may be rough enough to cause damage to the instrument. The apparatus should never be used to spud through bridges in the hole, and the speed of travel past dog legs and obstructions should be slow to avoid abnormal shocks and jars. The entire assembly must be kept clean, and out of the way of water and mud when stored, for contamination of the inside of the device drastically affects its performance. Lack of observance of such simple precautions has been found to be the greatest source of imperfect results.

Owned Instruments

Those concerns whose business is to maintain the reliability of their instruments take care to instruct the crews in their use; they inspect regularly all equipment, make repairs as soon as required, and do everything possible to minimize both the occurrence and the effects of abuse. Such a program would insure the operator of the same high efficiency in his own instruments, but this has been too much trouble for many operators. This lack of care on the part of the operator has produced a similar attitude in the crews.

Damage in transportation is a frequent result of careless handling of the instruments. No instrument can be expected to function after a ride over oil-country roads, during which the instrument has been battered, yet the simple precautions of providing suitable protective cases or even of racks in the tool houses are overlooked.

Neglecting to make minor repairs is another cause of instrument failure—failure which might be avoided by taking care to see that an instrument is not kept in use after some accident has laid it open to further, more serious damage. As a result, repairs finally may cost almost as much as a new instrument, and delays or relying on false indications may cost much more. Such expense can be avoided by assigning to some member of the crew the duty of reporting the need for repairs as soon as they are necessary, and holding him responsible for the condition of the equipment.

Other problems in the use of instruments on the rig are mostly a question of training of the personnel. This is particularly true of the various pieces of apparatus now available for mud control.

There are operators who, in the true sense of the word, have not become instrument-conscious, and, therefore, make no effort whatever towards care of such equipment. Their lack of attention to this problem is probably due to the fact that, as compared to the total cost of a well, instrument maintenance is but a small item. On the other hand, if these operators would realize that the unseen cost of instrument failure is not a negligible item in the total cost of a well, they soon would establish some systematic maintenance routine. The essentials of a good maintenance system are few and simple:

First: Instruct the crews. Vocational training along the lines of the Institute's program would be useful here.

Second: Fix the responsibility; everybody's job is nobody's job.

[1]Abstract of paper presented at nineteenth annual meeting, American Petroleum Institute, Chicago, November 17, 1938.

*Martin-Decker Corp., Long Beach, Calif.
†Lane-Wells Co., Los Angeles, Calif.

Operating Costs of Multi-cylinder Gas Engines[1]

By JAMES McNEILL†

APPROXIMATELY 2500 multi-cylinder gas engines are used for pumping oil wells in California. In 1932 there were less than 50. This increase is due to the low first cost and operating economy of multi-cylinder gas engines and to the development of individually-powered portable pulling equipment, which permits the use of lower-powered engines for pumping service.

Small operators began to use old automobile engines on their wells. These engines proved to be dependable and economical to operate, and in 1932 the industrial-engine manufacturers entered the field.

Sizes range from 100 to 800 cu. in. in displacement, with four, six, or eight cylinders. Loads as low as 5 hp. and as high as 75 hp. are being carried economically—using, of course, the proper size engine for the job. Four-cylinder, 250- to 400-cu.-in. engines predominate, but the present trend is toward six-cylinder engines because of their wider speed range and higher hp. output per cu. in. of displacement.

Table 1 is a summary of the operating costs of multi-cylinder gas engines as experienced by a California company. This company operates more than 250 engines in pumping service, has a trained personnel, and keeps accurate cost records. All the engines are the four-cycle type, and four different makes are represented. The engines have been grouped according to size and number of cylinders, and the operating costs are shown as averages per engine per day.

Two totals are shown; one includes all operating costs except fuel; the other includes all operating costs as well as fuel. This was done because in some fields gas fuel is not a true expense, but merely a bookkeeping charge; while in others the cost may be some figure other than $0.10 per 1000 cu. feet.

It is the author's opinion that the operating cost of an engine depends primarily upon revolutions per minute and cu. in. displacement, and that the brake mean effective pressure has little or no influence if kept below 60 lb. per sq. inch. For this reason, expressing operating costs in terms of a hp. day or hour has little significance. An engine operating with 25 lb. b.m.e.p. will develop twice the hp. with 50 lb. b.m.e.p. at the same speed of rotation, but the operating cost will remain virtually constant.

Information available does not indicate that operating costs increase as the engine grows old. The maximum length of service of the engines considered is six years. Engines properly applied and maintained can be made to run probably as long as repair parts are available. What the economical or useful life expectancy is has not been determined. It is generally held that ten years is a reasonable figure. Some operators believe that it may be 20 years.

Economical operation of multi-cylinder gas engines depends upon their proper application, and upon an intelligent, trained personnel to service them. The California Subcommittee on the Maintenance of Multi-cylinder Gas Engines recommends that engines be selected so that the b.m.e.p. will fall between 40 and 60 lb. per sq. in., with piston speeds not exceeding 1000 ft. per minute. Occasionally, small-bore engines are run with piston speeds of 1200 ft. per minute.

Relative economy of operating engines in pumping service depends upon the field service men. The practice of most California companies is to service the engines once a month. Servicing includes changing oil, greasing, inspecting the ignition system, checking compression, and minor adjustments and repairs. All repairs, whenever possible, are made in the field.

The costs presented are low, but not lower than those of many other California companies. Any operator who carefully will engineer the selection of engines, and who will train his service and maintenance personnel, can duplicate them.

†Union Oil Company of California, Santa Fe Springs, California.

[1]Abstract of paper presented at nineteenth annual meeting, American Petroleum Institute, Chicago, November 18, 1938.

Engine data						Average cost per engine per day: lubricating oil, repairs, maintenance						
Number engines in group	Average cu. in. displacement of group	Number of cylinders	Average speed in r.p.m.	Estimated hp. range of group	Average days service per engine	Lubricating oil at .68c per gal.	Maintenance and repair labor at $1.20 per hour	Maintenance and repair parts as billed	Total all operating costs except fuel	Range in which 68% of engines fall	Daily Cost fuel at 10c per M cu. ft.	Daily total all operating costs including fuel
2	113	4	1300	5	730	$ .10	$ .08	$ .02	$ .20	.....	$ .20	$ .40
15	217	4	1100	5-15	208	.11	.14	.02	.27	$ .14-$ .40	.40	.67
23	280	4	800	5-15	995	.17	.15	.04	.36	.29- .43	.36	.72
120	350	4	900	7-25	615	.22	.16	.05	.43	.27- .59	.37	.80
13	425	4	800	10-35	748	.18	.14	.05	.37	.27- .47	.47	.84
32	290	6	1100	10-30	198	.15	.15	.02	.32	.22- .42	.43	.75
23	428	6	1100	15-40	350	.31	.29	.05	.65	.40- .90	.55	1.20

Table 1. Summary of Operating Costs—Multi-Cylinder Gas Engines

Nature and Importance of Surface Forces in Production of Petroleum[2]

By FRANK C. BENNER*, WESLEY W. RICHES*, and F. E. BARTELL*

A KNOWLEDGE of the surface forces active at the interfaces between sand, oil, gas, and water can be useful in predicting optimum rates of production and in determining the most efficient method of utilizing the energy of gas and hydrostatic pressures.

The "surface tension" of a liquid is defined as the force exerted on a straight line of unit length in the surface, in a direction parallel to the sur-

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[2]Abstract of paper presented at nineteenth annual meeting, American Petroleum Institute, Chicago, November 18, 1938.

face but perpendicular to the line. The surface tension operates to maintain the surface area at a minimum. It is expressed in dynes per centimeter. The term "interfacial tension" is used to refer to the tension between two liquid phases in contact or between a liquid and a solid. Free surface (or interfacial) energy is a measure of the work done in forming a unit area of surface (or interface). It usually is expressed in ergs per square centimeter, and is numerically equal to the surface tension. Surface tensions of liquids and interfacial tensions between two liquids can be measured accurately and easily. Unfortunately, no satisfactory methods for the determinations of the tensions at the solid-gas and solid-liquid interfaces have been devised. It is possible, however, to measure the change in free surface energy when a unit area of gas-solid interface is replaced by an equal area of solid-liquid interface. This difference in surface tensions is called "adhesion tension."

The magnitudes of the adhesion tensions of water and oil, respectively, against a solid, determine whether a given solid will be wet to a greater extent by water or oil. The adhesion tensions of crude oil against silica indicate that, although oils from different sources may vary appreciably in their degree of wetting for silica, none so far investigated has an adhesion tension greater than that of water.

If, to a pure liquid, certain substances are added as impurities, the interfacial and adhesion tensions may be altered radically due to adsorption. Impurities will be adsorbed at an interface if such adsorption lowers the free surface energy at the interface. Substances composed of both a hydrocarbon group and some polar group are instrumental in lowering the interfacial tensions against water or silica of liquids such as the hydrocarbons—of which petroleum is chiefly composed.

Static Conditions and Surface Effects

The static condition of fluids in the reservoir presents a problem that is much less complex in nature than the dynamic problem. Water rises in the finer pores to various heights depending upon the diameter of the pores and the properties of the oil. This concept is based on the laws of rise of liquid in capillary tubes. For a given oil the interfacial tension, contact angle, and density are definite and constant and, hence, the water height is inversely proportional to the radius of the pores. Because sands contain a variety of different sized pores the height to which water may rise is very great. Thus, instead of a definite water-oil level, there is a gradation of water content ranging from 100 per cent water to ever-decreasing quantities as the height above non-capillary water-oil level increases. For different oils, the height to which the water may rise in a capillary of given size is dependent on the adhesion tension of the oil against sand and its density.

Surface Forces in Flow of Reservoir Fluids

The effect of surface forces on the dynamic conditions that exist when oil is being produced from the well presents a more complex and difficult problem. Water can be either a detrimental or a beneficial influence in the production of oil. Most efficient use of "natural flooding" consists in obtaining the proper balance of all forces involved—gas pressure, hydrostatic pressure, and surface forces—so that the advancing water-oil interface is essentially uniform and by-passes as little oil as possible.

In determining the optimum rate for water advance into oil-bearing sands, one of the most important points to be considered is the rate at which the water can strip the oil from the sand. If water is forced through the pores at a rate exceeding that at which complete stripping occurs, the water will channel through and drive part of the oil before it, but will leave behind—still adhering to the sand surface—a quantity of oil, which may exceed that displaced. The rate at which complete stripping of the oil from the sand by water occurs is certainly related to the wetting properties of the solid and liquid phases. The difference in adhesion tensions of water and oil for the sand is a measure of the energy change involved in the displacement, and is a factor to be considered. The rate is not a function of the adhesion tensions alone, however. The nature of the adsorbed material at the solid-oil interface and the manner in which it is held by the surface are probably the chief factors in controlling the rate of displacement. The viscosity of the oil may exert a modifying influence. The presence of various salts may improve the efficiency of the flooding process. In natural flooding, chemical treatment of the water is not a practical measure, but a knowledge of the salts present in the edge water and their effect on the rate of stripping oil from the surface by the brine would be an important factor in deciding optimum rates of production.

When water invades a sand of irregular texture containing oil, the oil is retained most persistently in those parts of the bed that are of relatively fine, close texture. Rapid invasion of water into oil sands is likely to by-pass tightly packed sand lenses—greatly affecting the thoroughness of recovery of oil from the reservoir. Such by-passing is due simply to the differential permeability of the sand. An exact reversal in thoroughness of recovery of oil from the different textures of sand should be the case if the rate of invasion is slow enough to permit equilibrium to set up, for the fine-grained sands possess a greater capillary attraction for water than do coarse-grained sands. As has already been demonstrated, water will attain a greater height in fine pores than in coarse ones. Likewise, a greater back pressure is required to halt completely the advance of water into fine pores that are essentially straight and production rates by regulation of back pressure should tend to lower the loss of oil due to retention in fine sand.

Microscopic variations in the texture of the reservoir can be a disturbing factor. The pores are not of uniform diameter. Rather, they are a network of intermeshing openings of various sizes, none of which is continuous for any great distance. For the sake of simplicity in treatment, however, two pores that are essentially straight and uniform are considered. One pore, r_2, has a radius several times that of the smaller pore, r_1. The pores are filled with oil, water entering at one end. The pores are interconnecting at the outlet. If a pressure is applied to the inlet end of the pores, the water interface will advance as the result of two forces—one the pressure gradient applied, and the other the force due to capillary attraction. When the applied pressure is great, we should expect a more rapid flow of liquid in the larger pore, with the result that the water-oil interface in tube r_2 would reach the junction of the two pores before the interface in r_1 and trap off a small quantity of oil in the small capillary. If the experiment is repeated in such a manner that only surface forces cause flow, a different situation is encountered. Due to the force of capillary attraction, the water-oil interfaces will begin to advance in both the large and small capillaries. If we attach a manometer or pressure-measuring device to the oil outlet, we shall see that, as the interfaces advance, a pressure is built up. For each capillary there is an equilibrium pressure at which advance will just cease. This pressure is a function of several factors. As the liquids advance, there will be built up eventually a pressure equal to the equilibrium pressure for r_2. This pressure is very much less than the equilibrium pressure for r_1; hence, the interface in r_1 will continue to advance and build up

pressure. As this pressure exceeds the equilibrium pressure for r_2, the interface in the larger capillary will begin to recede while the interface in r_1 is still advancing. Here we have liquid advancing in one tube and flowing back in the other tube without effective forward displacement. When the interface in the smaller tube reaches the juncture of the two pores, oil again will be trapped off.

The phenomenon of simultaneous flow in two directions actually was encountered in the course of experiments being conducted by the authors.

The conditions for optimum recovery depend upon the proper balance between the surface forces and other driving forces. If extremes in either direction are approached, serious loss of oil may occur. The proper balance between the two extremes is necessarily a function of the size distribution of the pores in the sand. The difficulties in obtaining the proper balance to give optimum recovery increase as the variation in pore size increases.

Hydraulic Decoking of Coke Chambers[1]

By W. F. COURT*

A NEW and improved method of disrupting and removing coke from coke chambers on cracking and coking units has been developed by the Shell Petroleum Corporation, and is now in commercial use.

The method consists of cutting the coke by means of high impact-producing water jets.

One of the striking features of the operation of this unit is the re-cracking of cracked residuum to gasoline and coke. Cracked residuum of approximately 4-deg. A.P.I. gravity is withdrawn from the flash chamber of the primary cracking section, and transferred to the bottom of the fractionating column on the coking section—where it mixes with the heavy re-cycle stock from the coke chambers. This material is then withdrawn by a hot-oil pump and charged to the Equiflux heater on the coking section, entering at a temperature of 760 to 780 deg. fahrenheit. It is further heated therein to a temperature of 925 to 950 deg. fahr. before entering the coke chambers. These chambers operate at a pressure of 125 to 135 lb. per sq. inch.

At present the four coke chambers on this unit are used in a 48-hour cycle, only one at a time being on stream. The others are cut-in when needed by means of switch valves, and in this manner the coking operation is carried on continuously. Each chamber is filled within 10 ft. of the top, equivalent to approximately 150 tons of coke. Two chambers are cleaned every day. The average length of runs on the coking section of this unit is 30 days, the longest run to date having been 45 days.

The conventional cable method formerly was used to remove the coke from the coke chambers on this installation. This method consisted of suspending layers of steel cable laid in spiral form throughout the chamber. At the end of the operating cycle, which in this case was about 9 hours, the chamber was valved off, and the pressure released. It was then steamed, and cooled with water—after which the cable was pulled by means of a hoist, thereby disrupting and removing the coke from the chamber.

The cable method has now been displaced by the hydraulic method of decoking, which was developed and worked out on 10-ft. by 40-ft. coke chambers.

In the hydraulic decoking method, the hydraulic cutting nozzles are attached to special tools mounted at the end of a hollow stem, to which water is supplied from a high-pressure header through a steel-piping linkage made flexible by ball-bearing swivel joints. This stem is suspended from an overhead structure mounted above the chamber, and is lowered and raised within the chamber by means of an air hoist.

The operation of removing the coke comprises essentially two steps, viz.:

1. Boring a hole downward through the coke bed.
2. Cutting and removing the coke from the chamber.

In the first step a hole approximately 18 in. in diameter is bored downward through the coke bed by means of a revolving cutting head or boring tool which derives its power from the reaction of water jets discharging horizontally.

The boring operation is made in two steps to save excessive height in the overhead structure, and is interrupted at a point halfway down through the coke bed, in order that the stem may be lengthened sufficiently to carry the operation completely through the bed. The water discharging from the nozzles of the boring tool drains readily through the coke bed, and out of the bottom manway.

In the second step, the boring tool is removed from the stem at the bottom of the chamber, and replaced with a part of the assembly of cutting nozzles. The complete cutting assembly of nozzles used in this operation is divided into two sections, a "top section" and a "bottom section." The "top section," which has two nozzles, is elevated into the chamber first in order to make an enlarged opening in the coke bed at the bottom of the chamber so that the "bottom section" of the assembly can enter. After an enlarged opening has been cut at the bottom of the coke bed, the stem is lowered and the "bottom section" of the assembly is attached to the "top section," and the complete cutting assembly is then raised into the chamber.

The nozzles in the "top section" direct their jets horizontally, and the streams of water penetrate the coke bed to the chamber wall. The nozzles are offset so that the reaction from the streams of water rotates the nozzle assembly, thereby cutting the coke bed into layers as the assembly is raised in successive steps by the operator. The "bottom section" has two nozzles pointing slightly upward at an angle, and serving to cut the coke away from the wall. As the coke is cut into layers by the revolving jets, it breaks away and falls to the bottom of the chamber.

The cutting operation is likewise interrupted at a point half-way up through the coke bed in order that the stem may be shortened sufficiently to carry the operation completely through the bed to the top of the chamber.

During the cutting operation the coke and water fall through the bottom manway of the chamber directly into side-dumped railroad cars. The movement of these cars is accomplished by means of an electric "car puller" controlled from a push-button station at the operating platform under the chambers.

The water draining from the coke cars falls onto a concrete floor, and the fine coke it contains is washed into trenches. The trenches are provided with flushing jets so as to wash the fines into a collecting pit. The coke fines accumulating in this pit are continuously withdrawn as a "slurry" by means of a special centrifugal pump,

*Shell Petroleum Corporation, St. Louis, Missouri.

[1]Abstract of paper presented at nineteenth annual meeting, American Petroleum Institute, Chicago, November 18, 1938.

and re-circulated back into a partly-filled or into a full coke car—where the coke bed in the car acts as a filter to collect the fines.

Water from the coke-fines collecting pit passes through a screen into another compartment of the pit, and is pumped to a settling tank—where a further settlement of coke fines is effected. Coke fines accumulating in this settling tank are likewise re-circulated as a slurry to the railroad cars. The clear water from the settling tank flows into a surge tank, from which it is again pumped by the high-pressure jet pump to the cutting nozzles in the chamber. The rate of flow to the cutting nozzles is approximately 700 gal. per min. under a pressure of 900 to 1000 lb. at the entrance of the nozzles.

Sometimes coke is so hard as to present difficulties in removal by the cable method. Such coke, however, readily is removed by the hydraulic method.

The percentage of lump- and egg-size coke produced by the hydraulic method is comparable with that produced by the cable method.

The hydraulic method has opened new possibilities for reducing greatly the degradation. It also has opened up a new method of transporting coke.

There are also very definite indications that the use of railroad cars for receiving and transporting coke to the storage yard or screening plant now can be done away with entirely. It has been demonstrated by tests that coke and water in the right ratio can be pumped by means of a special centrifugal pump to the coke pile, into hoppers, or directly to the screening plant.

Removal of coke by the hydraulic method revealed the following advantages over the cable method:

1. The clean-out time for the 13-ft. by 50-ft. chambers has been reduced at least 50 percent, and complete removal of the coke from a chamber within two hours' time is now a frequent occurrence—the record to date being 1 hour and 40 minutes. Any time saved in clean-out operations usually is an on-stream time gain.

2. The clean-out crew, including the men required for cleaning piping, etc., has been reduced from 20 to 11 men.

3. An important saving has been effected by eliminating the cost of cable, cable clamps, cable hooks, fastening wire, etc.

4. Cable-fastening wire, usually present in coke removed by the cable method, has been eliminated by the hydraulic method.

5. In the hydraulic method all coke is removed from the chamber wall by the jets; hence, men are not required to scale the coke from the wall.

6. With the hydraulic method it is not necessary for the clean-out crew to enter the chamber at any time; hence, one of the hazards to which this class of labor was formerly exposed has been eliminated.

The hydraulic pumps are driven by electric motors especially built for the cycle of operations. A standby high-pressure pumping unit is provided on the Wood River installation.

Experience to date indicates that the cost of maintenance of the jetting nozzles is very low. They are equipped with renewable tips which obviate the necessity for replacing a complete nozzle when wear occurs.

Tests have indicated that the cutting action of the jets has no effect on the steel walls of the vessels.

The swivel joints used in the piping linkage between the high-pressure header and the stem are standard equipment, and the expense for their maintenance to date has been negligible.

Corrosion Protection of Refinery Equipment[1]

J. A. JAMISON*

BECAUSE the problem of refinery corrosion is such a broad subject, is has been possible to deal only with the more common types of units, and the larger pieces of equipment.

CRUDE DISTILLATION

1. Furnace Tubes

Practically all furnace tubes used in crude-distillation units are made of low-carbon steel. The tubes average about ¼ in. thick, and last at least five years. If any trouble is encountered in the furnace, it is invariably from the flue gasses, which cause oxidation and scaling, rather than corrosion of the inside surface. Alloy-steel tubes with higher oxidation resistance are seldom used beyond a few trial tubes.

2. Bubble Towers

Corrosion in crude-distillation bubble towers, operating either under vacuum or at low pressure, is localized to the shell at: 1, the flash zone opposite the vapor inlet; or, 2, the top of the tower in the area of the reflux connection. The intermediate parts of the tower seldom suffer any noticeable attack.

The corrosion of the shell at the top of the tower is controlled, and very often reduced to nil, by the aid of an alkaline neutralizer for the hydrogen chloride liberated from the crude.

Trays and caps are made of either cast iron or carbon steel, and the corrosion follows that of the shell, viz., within the top three trays and the first and second trays above the flash zone. The life of these materials is generally over one year at these severest points of attack, and alloys are seldom employed.

3. Condensers

Wherever a coil-in-box condenser is used, the coil is normally constructed of cast iron. This material shows excellent resistance to corrosion on the water side.

Refiners with overhead condensing equipment consisting merely of a coil-in-box are seldom troubled with corrosion, once they have determined the proper amount of ammonia required for control.

When the overhead system is made entirely of tubular condensers, these are ordinarily constructed of cast-iron shells, Admiralty tubes, and Muntz or naval brass tube sheets. Baffles or spacers are also made of brass. To protect piping after the point of condensation, and particularly the top of the tower, ammonia is generally injected to the extent necessary to maintain the steam condensate at the pH value of 6.5 to 7.

Probably the most difficult problem with condensers is encountered by those plants that handle vapors with a combination of partial condensers equipped with carbon-steel tubes and total condensers containing Admiralty or red-brass tubes. All these plants add ammonia to the vapor stream.

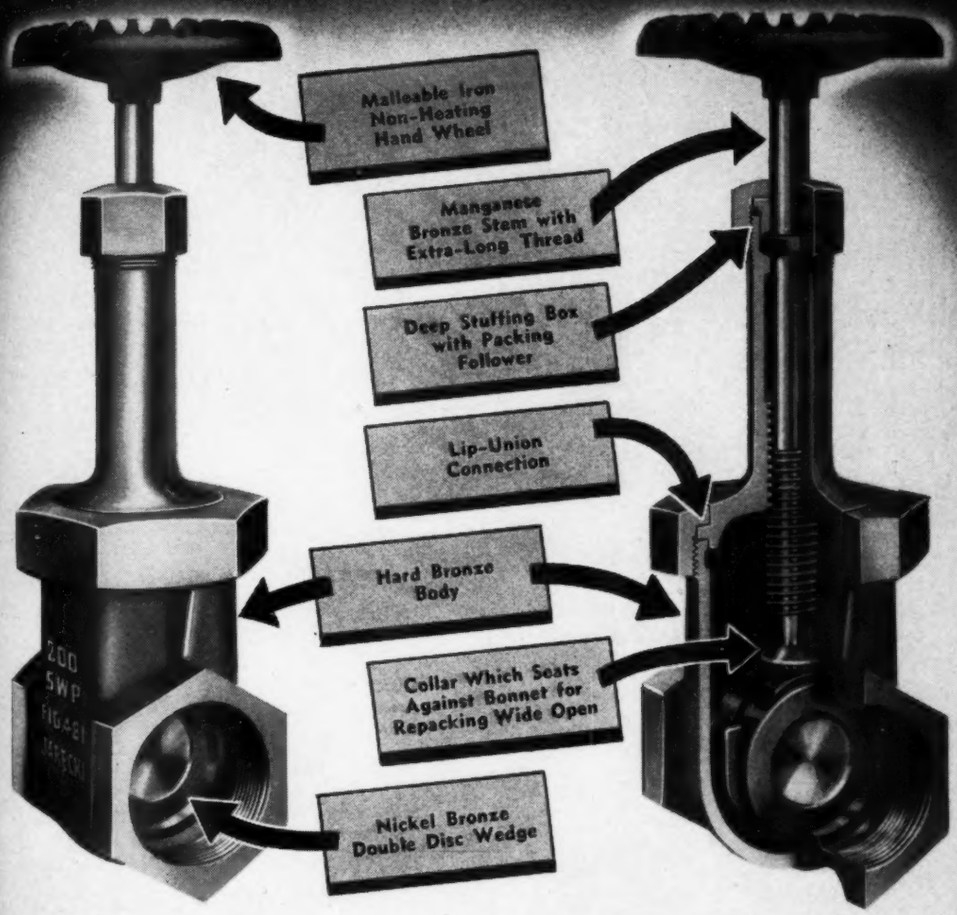
4. Exchangers and Coolers

Coil-in-box coolers are normally made of cast-iron pipe, and offer practically no corrosion problem. For tower "bottoms," which are often pumped, it is sometimes necessary to use carbon-steel pipe in place of cast iron. Ordinarily, very little trouble is experienced with steel from the oil side, but the

[1]Abstract of paper presented at nineteenth annual meeting, American Petroleum Institute, Chicago, November 17, 1938.

*American Petroleum Institute, New York, N. Y.

JARECKI offers a *new* HEAVY BRONZE GATE VALVE


Malleable Iron Non-Heating Hand Wheel
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Deep Stuffing Box with Packing Follower
Lip-Union Connection
Hard Bronze Body
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Nickel Bronze Double Disc Wedge
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JARECKI announces with pleasure this new, heavy bronze gate valve, primarily designed for refinery and natural gasoline plant service for positive shut-off of gasoline, propane and other volatile oils.

This valve is a distinctly superior product. Body is of hard bronze, high in tin content, with a tensile strength of 35,000 lbs. Stem is of Manganese bronze. Discs are durable nickel bronze, and renewable. The lip-union connection between bonnet and body provides an exceptionally tight and strong construction. Stuffing box has deep recess for packing, assuring tightness.

Designed for 200 lbs. S. W. P.; 400 O. W. G. working pressures.

The JARECKI line of brass, bronze and hard bronze valves and fittings includes every type of globe, gate, check, and safety valve, and every type of cock and fitting required for oil industry service.

Fig. 450
Standard Bronze
Gate Valve

Fig. 414
Heavy Standard
Bronze Globe Valve

Fig. 424
Bronze Regrinding
Swing Check Valve

Fig. 426
Heavy Standard
Bronze Check Valve

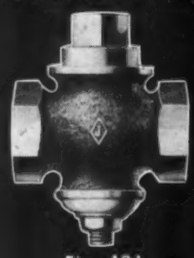

Fig. 491
Heavy Standard
Bronze Steam Cock

Fig. 326-A
Brass Tee
125 Lb. S. W. P.

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pipe may corrode from the water side, particularly at that end of the coil where the hot oil is introduced — usually the top row. Occasional replacements are made with carbon steel, and in some cases salvaged alloy tubes from cracking furnaces are utilized.

Tubular coolers, with water as the cooling medium, in the majority of cases are made of Admiralty tubes. Failures, in general, occur from the water side through dezincification.

Tube sheets are made of Muntz or naval brass; the spacers are either brass or carbon steel, inasmuch as no water is present.

Exchangers in oil-to-oil (liquid-to-liquid) service are made of carbon-steel tubes, regardless of the type of crude. A life of five or more years is not uncommon.

5. Salt Removal

Difficulty with salts in crude is slowly affecting an increasing number of plants. Observation of several plants leads to the conclusion that the salt content of crudes as received at the distillation unit usually increases at a gradual rate over a period of months. There is no sharp line of demarcation at which the problem becomes accutely disconcerting. The customary procedure is to increase back pressure on the pre-heated crude in order to prevent vaporization of water and deposition of salts.

CRACKING AND VISCOSITY BREAKING

1. Furnace Tubes

Insufficient wall thickness to withstand required stress is the most frequent reason for tube condemnation. The metal on the inside surface is lost through corrosion.

When a change has taken place in the structure of the steel, failure of a tube may occur despite the presence of sufficient wall thickness. Fortunately, this type of trouble is rare. Imminent failure from this source can be detected only by sacrificing occasionally a few tubes for a metallurgical examination.

The thickness may also increase after the tube has been in service, due to the formation of an oxide scale. Such tubes, however, lack strength despite sufficient wall thickness.

Pronounced enlargement of the outside diameter in the form of a "bulge" is usually sufficient cause to condemn a tube.

When the furnace is equipped with an improper burner setting, the heat is not evenly distributed, but concentrated in localized areas. A "hot spot" is produced in the tube.

2. Protecting Cracking Tubes

When lime is used as the remedial measure, the common practice is to mix the neutralizer with a small batch of the feed stock to form a slurry.

The general practice in refineries is to substitute alloy tubes for carbon-steel tubes only in the critical section of the furnace. Only where the corrosion rates of carbon steel are exceptionally high throughout the entire furnace is it necessary to employ alloy tubes in the entire coil.

3. Cracking Vessels

Horizontal chambers operating on Mid-Continent stocks seldom exceed a maximum corrosion rate of 0.02 in. per 1000 stream hours for carbon steel. In horizontal chambers there is a tendency for the rate to increase from the inlet to the outlet end.

In vertical chambers the maximum corrosion is found at the top of the vessel, i. e., the top head and approximately 10 ft. of the shell. This condition is found whether the inlet and outlet vapor nozzles are located in the top head, or the flow of vapors is up or down through the vessel. Corrosion rates in vertical vessels are about the same as those in horizontal chambers operating under similar conditions. The highest corrosion rate reported for any carbon-steel vessel is 0.15 in. per 1000 stream hours.

The location of the maximum corrosion in an evaporator is dependent upon the design of the vessel. In the most common type the products from the transfer line are discharged directly into a flash zone, and the maximum wear will be found opposite the vapor inlet.

Corrosion in practically all cracking bubble towers is localized to that portion of the shell below the liquid-fresh-feed inlet. The rates above this point are often of negligible proportions. The trend of corrosion is found to increase gradually from the liquid-feed tray down through the tower to a maximum in the flash zone opposite the vapor inlet. Sometimes the maximum wear extends through the stripping section to the shell below the liquid level. As a rule, however, the rates below the liquid level are slightly less than those opposite the vapor inlet.

4. Protecting Cracking Vessels

Probably the most frequently employed preventative is a gannister lining. An average life of this form of protection is about four years, with patching required generally within the first year.

Lining the interior of vessels with 11-13 chromium is slowly being adopted by an increasing number of plants. The liner ordinarily used is approximately 1/10 in. thick. Some of the first installed liners are still in service after 70,000 hours' operation.

When lime is used to protect furnace tubes, a beneficial result is sometimes also observed in the towers. With Mid-Continent stocks, the corrosion rates of the shells without the neutralizer are ordinarily so low that the effect of lime is obscured.

The installation of ¼- to ½-in. carbon-steel plates by tack welding to the shell was tried by a few plants. These linings generally require renewal after about one year of service due to excessive buckling.

Protection of the surface is obtained by metal spraying if the coating does not peel. The three most common places of application are in reaction chambers, evaporators, and the base of bubble towers.

5. Condensers and Coolers

Many of the older cracking units, which constitute the largest number, are comparatively barren of tubular exchangers and coolers, using instead coils-in-boxes. Carbon steel is ordinarily used for the coils. Corrosion inside the tubes is seldom a major problem. There is usually sufficient encrusting salts in the water to form a protective coating against corrosion for the outside of the tubes.

The materials most commonly used in tubular exchangers and condensers are carbon steel (oil as coolant) and Admiralty metal (water as coolant).

Corrosion of carbon-steel tubes ordinarily occurs on the vapor side of partial condensers, sometimes necessitating the use of 4-6-chromium—½-molybdenum tubes. As a general rule, carbon steel proves satisfactory for oil-to-oil (liquid-to-liquid) exchangers.

Admiralty tubing suffers from the same trouble as at the crude-distillation units, viz., dezincification from the water side.

GASOLINE-RECOVERY AND STABILIZATION PLANTS

Corrosion in gasoline-recovery and stabilization plants is ordinarily of small magnitude. The most frequent source of trouble is found on the water side of tubular units. Admiralty tubing is almost always used together with fresh water.

Liquid-to-liquid exchangers are made of Admiralty or carbon-steel tubes, and either material is often in service for five years without serious trouble.

Reboilers are ordinarily made of Admiralty metal when steam is used as the heating medium. Life varies from two to four years. Because higher metal temperatures are attained when circulating hot oil as the reboiling medium, the tubes are constructed of carbon steel. If this material proves unsatisfactory, it is customary to resort to 4-6-chromium-½-molybdenum.

Debutanizers, absorbers, and stabilizer towers are rarely troubled with corrosion. Any attack is usually localized, and in the order of 0.001 in. to 0.003 in. per 1000 stream hours.

Slightly higher rates are occasionally reported in towers operating as stills to strip the light gasoline from rich or fat absorber oil. "Open" steam is used in the base of these vessels, and corrosion is likely to occur in the top of the tower when conditions are suitable to cause condensation of steam.

RE-RUN UNITS

The corrosive agent in distillation units that are employed to re-run pressure distillate that previously has been stabilized, acid-treated, and neutralized is chiefly sulphur dioxide. Corrosion manifests itself particularly in the lower temperature ranges, where the vapor and steam are condensed, and in the top of the bubble tower. If the distillate on standing in the rundown tanks reverts to the acid side, corrosion of the charge pump and the furnace tubes may also be encountered.

Both aqueous caustic and, to a much greater extent, anhydrous ammonia are used in re-run units to combat corrosion. With the aid of neutralizers, the corrosion rates in tower shells, furnace tubes, and condensers may be held to almost nil.

The material ordinarily used for trays, caps, and condensing coils is cast iron. Those caps and sections of the cooling coil which occasionally fail from graphitization are merely replaced.

Study of the Recovery of Oil from Spent Percolation Filters

By C. M. RIDGWAY, L. M. HENDERSON, and W. B. ROSS, The Pure Oil Company, Chicago, Illinois

A STUDY was made of one of the important factors influencing percolation costs, viz., the recovery of the oil remaining in the filter when the adsorbent is spent. In the process of this investigation the factors involved in the two operations of filter draining and filter washing were studied.

The following general observations and conclusions were drawn from the data obtained.

1. In plant filters the rate of draining and the total amount drained are dependent primarily upon the condition of the screen.

2. In naphtha washing a low uniform washing rate is desirable.

3. The first portion of the washing naphtha should be applied at a temperature below that of the filter, and in such volume as is necessary to remove the filterable oil. The subsequent washing naphtha should be added at a temperature above that of the filter for the purpose of dissolving an increased proportion of the tar.

4. A paraffinic naphtha of low vapor pressure and low end point should be used in washing.

5. An appreciable increase in the viscosity of the original charge increases the amount of naphtha necessary to reduce the oil content of the filter to a specific magnitude.

6. The color of the cylinder stock recovered in the clay wash is not indicative of its filterability.

7. The filterability of the oil contained in the washings is at present the only criterion that can be used in judging the fraction to be returned to the blend tank for reprocessing.

8. Clay-wash cylinder stock should not be blended with stocks of better filterability, inasmuch as this material decreases the filter yields to a much greater extent than its arithmetical proportion.

9. When re-cycle wash is used, extreme care must be taken to avoid introducing into the system material of poor filterability.

Revivification Characteristics of Bauxite Used in Percolation Filtration

By R. H. HUBBELL, JR., and R. P. FERGUSON, Attapulgus Clay Company, Philadelphia, Pennsylvania

INVESTIGATION of the effect of continued revivification on the adsorptive qualities of bauxite reveals that the revivification characteristics of this material vary with the type and source of stock handled and the method of filtration substantially as follows:

a. In the solution percolation of residual stocks bauxite retains throughout its life an efficiency of approximately 85 percent of its initial value.

b. In the straight percolation of bright stocks, average values in the vicinity of 80 percent of new material are obtained.

c. The bauxite filtration of distillate stocks requires the maintenance of low temperatures of revivification. Under optimum conditions values of 55 to 60 percent of No. 1 bauxite are maintained in the percolation of Pennsylvania neutrals.

d. Bauxite manifests a great advantage over other adsorbents in the percolation of petrolatums and related stocks, owing to the high yields and the tasteless and odorless character of the products.

e. Fresh bauxite exerts a "solvent" action greater than that of Fuller's earth, a characteristic that diminishes with repeated reburning. With fresh material, improved carbon and increased A.P.I. gravity are obtainable, but only at some sacrifice in viscosity.

Hydrocarbons in the Lubricant Fraction of Petroleum

By FREDERICK D. ROSSINI, National Bureau of Standards, Washington, D. C.

THE results are summarized of an experimental study, covering a period of five years, of the chemical constitution of the lubricant fraction of a Mid-Continent petroleum, which has been carried on as one of the problems of the American Petroleum Institute Research Project 6 at the National Bureau of Standards. A complete analysis with respect to size and type of molecules has been made of both the "water-white" oil and "extract" portions, which together constitute about 57 percent of the entire lubricant fraction. The kinds of molecules in the "wax" portion, which constitutes about 35 percent of the lubricant fraction, are known in a general way, but much less definitely than those in the "water-white" oil and "extract" portions. The kinds of molecules in the "asphaltic" portion, which constitutes about 8 percent of the lubricant fraction, are surmised. The significance and interpretation of the data are discussed. It is pointed out that, in terms of significant amounts, every hydrocarbon in the "water-white" oil and "extract" portions contains one or more naphthene rings, which is to say that there are no purely paraffinic or aromatic hydrocarbons in these portions.

Taking the lubricant fraction as 100 percent, the following approximate average analysis with respect to the kinds of molecules in this Mid-Continent petroleum is reported:

1. About 43 to 51 percent is composed of molecules with one, two, or three naphthene rings, together with the appropriate paraffin side chains.

2. About 8.3 percent is composed of molecules with one, two, or three naphthene rings and one aromatic ring, together with the appropriate paraffin side chains.

3. About 8.1 percent is composed of molecules with two naphthene rings and two aromatic rings (condensed) together with the appropriate paraffin side chains.

4. About 6.6 percent is composed of molecules with one naphthene ring and three aromatic rings (condensed) together with the appropriate paraffin side chains.

5. About 18 to 26 percent is composed of normal (straight-chain) paraffins, plus possibly some *iso*paraffins (branched-chain).

6. About 8 percent is composed of the "asphaltic" constituents, which have not been investigated.

Control of Wax-Distillate Quality

I. The Analytical Separation of Wax and Oil

By E. A. BURCH, Continental Oil Company, Ponca City, Oklahoma

II. Experimental Control of Slack-Wax Sweating

By J. W. DONNELL, University of Oklahoma, Norman, Oklahoma; and E. A. BURCH, Continental Oil Company, Ponca City, Oklahoma

III. Control of Lubricating-Oil Distillates by Vacuum Distillation

By L. L. DAVIS and ANTON NELSEN, Continental Oil Company, Ponca City, Oklahoma

IV. Survey of Oklahoma Wax Distillates

By J. W. DONNELL, University of Oklahoma, Norman, Oklahoma

THE laboratory and pilot-plant methods of controlling the quality of wax distillates developed and used by Continental Oil Company and a survey of five Oklahoma wax distillates by the Chemical Engineering Department of the University of Oklahoma are given in four sections:

I. The analytical separation of wax-oil mixtures is discussed, and methods presented for the selection of the correct solvents and for the determination of the theoretical yield of wax of any desired melting point from a given slack wax.

II. A pilot sweating plant is described, and the various factors affecting the yields of scale wax from the sweating operation are discussed.

III. A modified vacuum-distillation apparatus is described, and the use of the apparatus for the examination of wax distillate discussed. The relationship between viscosity and mid-distilling temperature is recommended as a basis for the estimation of pale oil yields.

IV. The analytical methods described and the University of Oklahoma pilot-plant equipment are used to study the characteristics of five Oklahoma wax distillates. The results show great difference in quality, based both on possible pale oil and on wax yields.

Partial Volumetric Behavior of the Lighter Hydrocarbons in the Liquid Phase

By B. H. SAGE, B. L. HICKS, and W. N. LACEY, California Institute of Technology, Pasadena, California

THE prediction of the specific volume of homogeneous and heterogeneous complex hydrocarbon mixtures is of importance to the petroleum technologist. The partial specific volumes of each of the components in both the liquid and gas phases are of value in making such predictions. The partial volumes of the paraffin hydrocarbons from methane through pentane in the liquid phases of the various hydrocarbon systems that have been studied experimentally are presented in tabular form, together with similar information for two complex liquids. A tentative correlation of these partial volumes has been prepared to permit the prediction of the specific volume of naturally occurring hydrocarbon liquids in the ranges of pressure and temperature that commonly are encountered in production practice. This correlation represents a preliminary attack upon one part of the major problem of the prediction of the volumes of hydrocarbon mixtures under widely varying conditions.

The Value of Soil-Survey Methods

By J. M. PEARSON, Sun Pipe Line Company, Philadelphia, Pennsylvania

THE paper summarizes the type of information upon which modern soil-corrosion tests are made. From this background two approaches are open to the corrosion technologist. He may: 1, examine data on corrosion experience to deduce certain constants to define soil corrosiveness; or, 2, he may correlate these constants (corrosivity) with soil measurements made in the field.

Having established those criteria most suitable to the corrosion survey required, a method is described that will evaluate the survey in terms of operating costs and investment charges.

The work of many able investigators is discussed in the hope that corrosion technologists will become interested in making quantitative measurements of the effects of corrosion in different soils. How this may be done is indicated.

Some of the pitfalls awaiting unwary users of statistical formulas are noted, and a method by means of which extrapolations can be criticized is given.

Factors Influencing the Application of Pumping Units

By EMORY KEMLER, Gulf Oil Corporation, Tulsa, Oklahoma

THE application of pumping units on the basis of peak-torque requirements is the most satisfactory method available to date. Actual well tests included show that the use of maximum well load for figuring peak torque does not give representative results at higher speeds. The theoretical investigation of the effect of prime mover on peak torque shows that the engine coefficient of fluctuation should be the basis for correcting horsepower ratings, rather than the number of explosions per minute.

The A.P.I. specifications state that the rating of gear units applies only when there is an absence of torsional vibrations. This paper gives a theoretical investigation of this problem, and shows that torsional vibrations can exist in the geared systems as used on pumping units. Experimental data given show that, when rotary counterbalance is used, these critical speeds or torsional vibrations can exist.

The Anti-Knock and Mixture-Distribution Problem in the Multi-cylinder Engine

By A. J. BLACKWOOD, O. G. LEWIS, and C. B. KASS, Standard Oil Development Company, Elizabeth, New Jersey

PAST surveys by the Institute indicated the probability that significant reduction in the average anti-knock requirements of cars might be effected without making any major changes in the engine. This paper describes extensive studies of ignition-system characteristics and gasoline-mixture distribution as affecting de-

tonation. The results have brought out the following pertinent points:

1. Variations actually occurring in the spark advance from cylinder to cylinder may vary the octane-number requirement by about 10 points.

2. Even with perfectly synchronized spark advance to all cylinders, the variation in mixture strength reaching individual cylinders during full-throttle operation may cause a variation of about 15 points in octane-number requirements.

3. With the particular test engine used, mixture distribution could be improved markedly only by going to excessively high fuel volatility.

4. Apparently, present-day cars are not capitalizing on the continued efforts of the petroleum industry to provide fuels of better volatility and higher octane number.

5. Care in assembling present-day cars at the factory could bring about an average decrease in octane-number requirement of several points. This, in turn, could be utilized in future designs to permit of higher compression ratio and increased efficiency.

Evaporation Losses of Petroleum Oils from Steel Tanks

By C. C. ASHLEY, Shell Oil Company, San Francisco, California

SUMMARY: The study upon which this report is based was undertaken in an effort so to correlate and compare all available data on tank evaporation losses that charts might be prepared to assist in the prediction of evaporation losses from petroleum oils in standing storage and while these oils are being pumped into tanks.

Conclusions: A detailed review of a large amount of data on evaporation losses indicates that much of the information that has been published as comparable is not comparable, because there has been no common basis for comparison. Methods of presentation used have not included enough of the many variables affecting evaporation losses to insure results truly representative or comparable.

The charts presented herein are based on a factor that is believed to be the most comprehensive of any so far used in this work, and upon which adequate correlation of tests made under widely variable conditions can be accomplished. This factor is "vapor pressure of oil at average temperature of oil in tank."

Two charts, which can be used for the prediction of losses, are presented: "evaporation loss of petroleum oils from standing storage in steel tanks," and "evaporation loss of petroleum oils due to pumping into steel tanks." The data upon which these charts have been prepared are rather meager, and the charts, consequently, are subject to revision as additional information becomes available.

Incidental to the preparation of the charts, it has become evident that there is a real need for a uniform procedure for conducting evaporation-loss tests that can be adopted generally, and that will facilitate coördination of results obtained by different investigators. A suggested procedure is presented in the appendix to this report.

Report on A.P.I. Pump-Performance Experiment

By M. G. ARTHUR, Standard Oil Company of California, La Mirada, California, and E. K. PARKS, Standard Oil Company of California, Los Angeles, California

THIS paper describes the procedure and results of an American Petroleum Institute cooperative experiment on reciprocating-pump performance, conducted in an effort to show the influence on liquid pumped of such factors as: 1, fluid head on the standing valve; 2, viscosity; 3, velocity through the standing valve; and, 4, size of standing-valve opening, and size and length of any tubes leading to the standing valve.

It is stated that results of the test indicate that no serious loss of efficiency should be found in practice unless the proportions of sound design are disregarded, such as attempting to pump very viscous liquid at high speed with low fluid head.

The Calculation of Venting Requirements for Low-Pressure Oil-Storage Tanks

By LOUIS BOSA, Shand and Jurs Company, Berkeley, California

OIL storage tanks "breathe" on account of temperature variations or during filling and emptying operations. Breather valves allow a tank to breathe while limiting at the same time the evaporation losses. The size and number of breather valves required in a certain installation depend upon the maximum probable breathing rate, in cubic feet per hour.

An investigation of the methods used for the calculation of venting requirements has led the author to submit a "standard method of calculation," flexible enough to fit varying conditions, and insuring at the same time the necessary degree of safety. A nomographic chart is appended to simplify the numerical computations.

Sub-surface Sampling

By D. L. KATZ, University of Michigan, Ann Arbor, Michigan

THIS paper is an abstract of the Report of the Sub-committee on Fundamentals of Obtaining, Transporting, and Analyzing Sub-surface Samples of Crude Oil prepared for the Topical Committee on Production Technology. It discusses the fundamental principles underlying the behavior of complex hydrocarbon systems for the purpose of providing a basis for critical review of the methods of obtaining, transporting, and analyzing sub-surface samples of crude oil. Recommended terminology and methods of reporting data on sub-surface samples are included.

Continuous Coking of Residuum by the Delayed Coking Process

By R. J. DIWOKY, Standard Oil Company (Indiana), Whiting, Indiana

PLANT application of the continuous "delayed coking" process is described. This process, which offers many advantages over earlier batch-still methods, is accomplished by passage of the charging stock through a furnace into one of several vertical drums in which coking takes place. Coke removal is effected by cable pulling.

Solubility Relations and Volumetric Behavior of Three Gravities of Crudes and Associated Gases

By J. E. GOSLINE, Standard Oil Company of California, San Francisco, California; and C. R. DODSON, Standard Oil Company of California, La Habra, California

SOLUBILITY relations and volumetric behavior of three gravities of crudes and associated gases obtained from a California sand of upper Miocene age were experimentally determined. The measurements were made for a series of pressures, temperatures, and gas-oil ratios. To illustrate the nature of influence of residual crude gravity upon certain of the more commonly used engineering factors, several correlations are indicated. Values of formation volume are tabulated, and factors for converting formation volume to specific volume are included.

LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

Simile

Mr. Frisch: How's the team coming?

Coach: Like counterfeit money—the halves are full of lead and the quarters can't pass.

Handicapped

"Are we going to try out young Roberts for the football squad?" asked the captain.

"No," replied the coach; "anybody who can spell such words as plenipotentiary, erysipelas, and plebiscite is no good as a football player."

My, How He's Grown!

Mrs. McTavish was making the last payment on the baby buggy and the clerk, in line of duty, thought it best to converse, "And how is the baby, Mrs. McTavish?"

"Oh, he's just fine; he's getting married next week!"

Individuality

Football Coach (to players): "And remember, boys, that football develops leadership, initiative, and especially individuality. Now get out there and do as I tell you."

The Alternative

Whipper: My college son is poor at football and worse at track.

Snapper: He might as well go in for an education.

Auctioneer: What am I offered for this beautiful bust of Robert Burns?

Man in crowd: That ain't Burns; that's Shakespeare.

Auctioneer: Well, folks, the joke's on me. That shows what I know about the Bible,

Affectionate

Diner: This steak is not very tender.

Waiter: Well, did you expect it to put its arms around you and kiss you?

—*Pup.*

An insurance salesman tells about a valuable wardrobe that his firm insured for a client during a European trip. Upon reaching London she wired: "Gown lifted in London." After due deliberation he sent this reply: "What do you think our policy covers?"

City Banker (visiting the farm): I suppose that's the hired man?

Farmer (who had visited bank): No, that's the first vice-president in charge of cows.

If those old-fashioned girls were so innocent, how did they know when to blush?

Easterner: Is it really healthy out here?

Cowboy: Say, we had to shoot a couple of fellows to start a cemetery.

"Mother," cried little Mary, rushing into the farmhouse they were visiting, "Johnny wants the Listerine. He's just caught the cutest little black and white animal, and he thinks it's got halitosis."

"I see where a Chicago man proposes that a badge be given every person who pays all of his taxes promptly."

"Huh! A barrel would be more appropriate."

Sonny sat on the lower steps, his face resting in his two chubby hands.

"What's the matter, Sonny?"

"Nothin'—just thinkin'."

"What about?"

"Thinkin' how dumb trees are to take off their clothes in winter and put 'em on in summer."

"A fan dancer is just a nudist with a cooling system."

Lady (to guide in Yellowstone Park): Do these hot springs ever freeze over?

Guide: Oh, yes. Once last winter a lady broke through the ice and burned her foot.

"Papa, are you growing taller all the time?"

"No, my child, why do you ask?"

"Because the top of your head is poking up through your hair."

"Little boy, how old is your mother?"

"Aw, she was forty-two, but she's marked down to twenty-seven."

Scotch Politician (tendering a lighted cigar): Take a wee puff laddie and give me your vote on election day.

"Teacher, may I leave the room?"

"No, Henry, you stay right here like a good boy and fill up the ink wells."

It was home talent night at the village concert, and Abner played a selection on his trombone. As the lengthy applause died down, a voice from the back called, "Give us 'Annie Laurie,' Abner."

"What?" asked Abner, surprised and flattered, "again?"

Mistress to new maid: Now, Nora, when you wait on the guests at dinner, please don't spill anything.

Nora: No Ma'am, I won't say a word.

A new British motor car has been designed that has no clutch or transmission. If it is without brakes, lights, or a horn, we've already seen it.

Bookplate

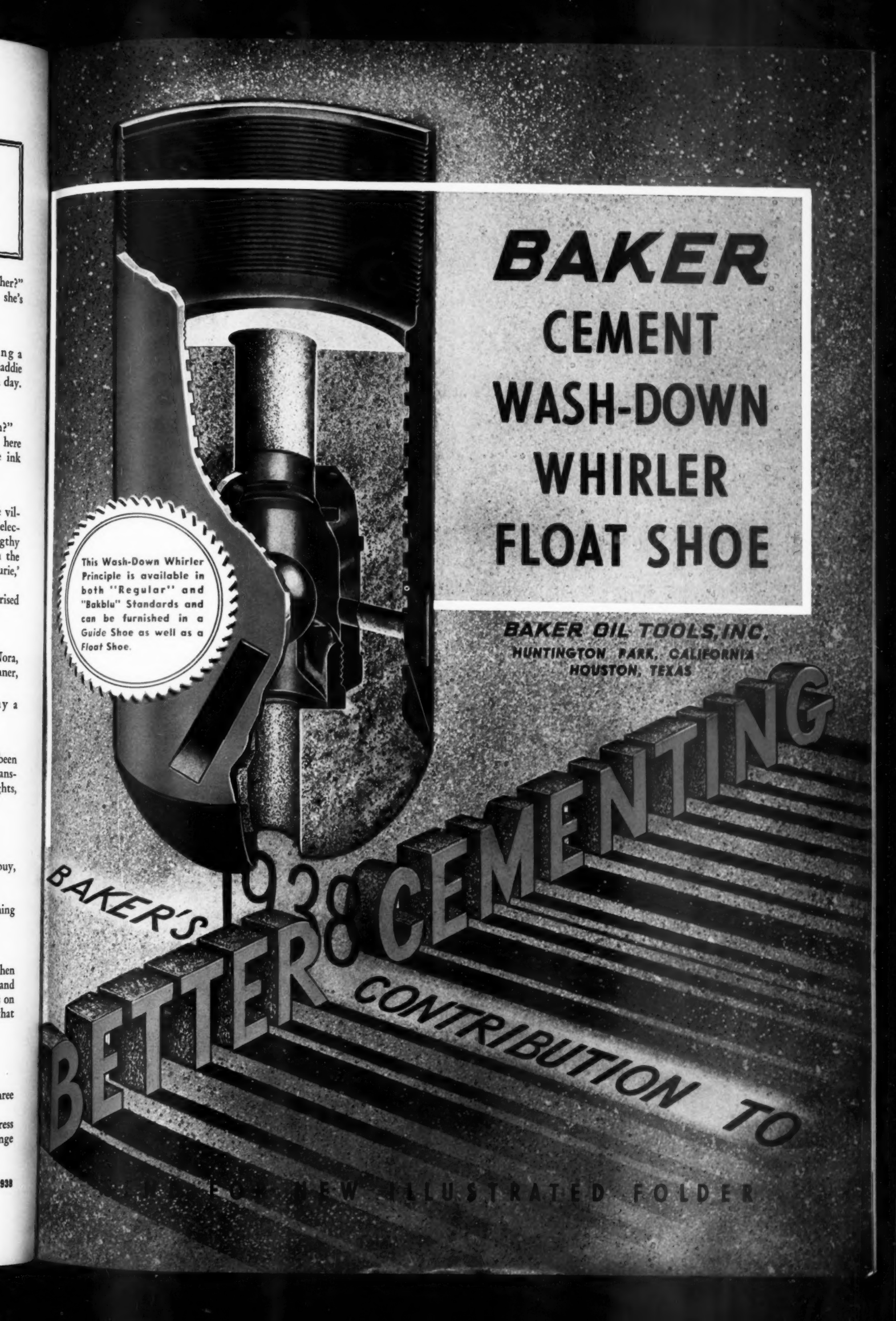
They borrow books they will not buy,
They have no ethics nor religions.
I wish some kind Burbankian guy
Would cross my books with homing
pigeons.—*Carolyn Wells.*

It is going to be pretty tough when this country gets back to normal and the fellows who write those articles on economics have got to know what they're talking about again.

Shopping

"You broke into the same store three nights running?"

"Yes, Judge; I stole only one dress for my wife and she made me change it twice."


BAKER
CEMENT
WASH-DOWN
WHIRLER
FLOAT SHOE
This Wash-Down Whirler Principle is available in both "Regular" and "Baklu" Standards and can be furnished in a Guide Shoe as well as a Float Shoe.
BAKER OIL TOOLS, INC.
HUNTINGTON PARK, CALIFORNIA
HOUSTON, TEXAS
1938 CEMENTING
BAKER'S BETTER CONTRIBUTION TO
FOR NEW ILLUSTRATED FOLDER

Running Tour
WITH MEN IN THE INDUSTRY

WALTER SHUTTS, material engineer for the Standard Oil Company of New Jersey in New York City, has been transferred to Venezuela as chief petroleum engineer. **JOE HOLMES,** who was at Caripito for the same company, has been transferred to Caracas. **M. L. HAIDER,** formerly chief petroleum engineer with the Carter Oil Company at Tulsa, Oklahoma, has been transferred to New York City.

R. D. MATTHEWS, executive vice-president of Union Oil Company of California, has announced the appointment of **EARLE W. GARD** to the post of director of research and development. Gard, who has been development engineer for the company for the last eight years, is a graduate of University of Southern California, and during the war served as an engineering officer in the U. S. navy.

EARLE W. GARD

E. E. NEWPORT, of the Sinclair Prairie Oil Company, has been elected chairman of the McPherson chapter of the American Petroleum Institute, succeeding **MAX SHERWOOD** of the Shell Petroleum Corporation. All other officers were re-elected.

J. C. JOHNSTON, Fort Worth, Texas, division superintendent for the Continental Oil Company, has been transferred to Denver, Colorado, as general superintendent of that area, to succeed **R. S. SHANNON,** who has left the Continental organization to enter the oil business for himself. **H. B. HURLEY** succeeds Johnston at Fort Worth. **R. L. CARPENTER** has been promoted to district superintendent in West Texas.

H. E. LINAM, general manager of the Standard Oil Company of Venezuela, having his headquarters at Caracas, is a United States visitor.

L. P. ST. CLAIR, for eight years president of the Union Oil Company of California, asked at the regular meeting of the board of directors to be relieved of his presidential duties. St. Clair was then elected chairman of the board of directors and in that capacity will continue actively in the affairs of the organization. **REESE H. TAYLOR** was elected as his successor. Taylor was elected to the board of directors of Union Oil Company in 1937 and has had varied experience with other business concerns.

A. E. CHESTERS, who has been in charge of the Socony-Vacuum Oil Company's operations in Illinois, Michigan, and Kentucky, has moved his headquarters from Mt. Pleasant, Michigan, to St. Elmo, Illinois. **KURY D. DeCOUSER,** Lansing, Michigan, will in the future be in charge of operations in Michigan and **CHARLIE ELLIS** will continue as superintendent for the Michigan district, having offices at Clare, Michigan.

DR. ANDREW COWPER LAWSON, professor emeritus of geology and mineralogy at the University of California, has been awarded the Penrose Medal, highest honor of the Geological Society of America.

J. W. HOUSE has been made division superintendent in charge of the West Texas-New Mexico division by the Humble Oil and Refining Company to succeed **W. T. DOHERTY,** resigned. Doherty will enter the oil business as an independent operator. House has been assistant division superintendent of the West Texas-New Mexico Division.

F. G. WHITE, district foreman in North Louisiana for the Magnolia Pipe Line Company, making his headquarters at Shreveport, has been transferred to Salem, Illinois, and will become superintendent of the gathering system being constructed in the Lake Centralia field.

W. H. FERGUSON, executive vice-president of the Continental Oil Company, has been chosen president of the recently organized Rocky Mountain Pipe Line Company, which owns and will operate the new Lance Creek-Denver line. **J. G. DYER,** in charge of production and lines for Continental, is vice-president of the new company; **GEORGE F. SMITH,** vice-president and treasurer of Continental, is secretary-treasurer; and other officials include **C. U. BAY,** head of the Bay Petroleum Corporation, and **FRED GOODSTEIN** of the Minnelua Oil Corporation.

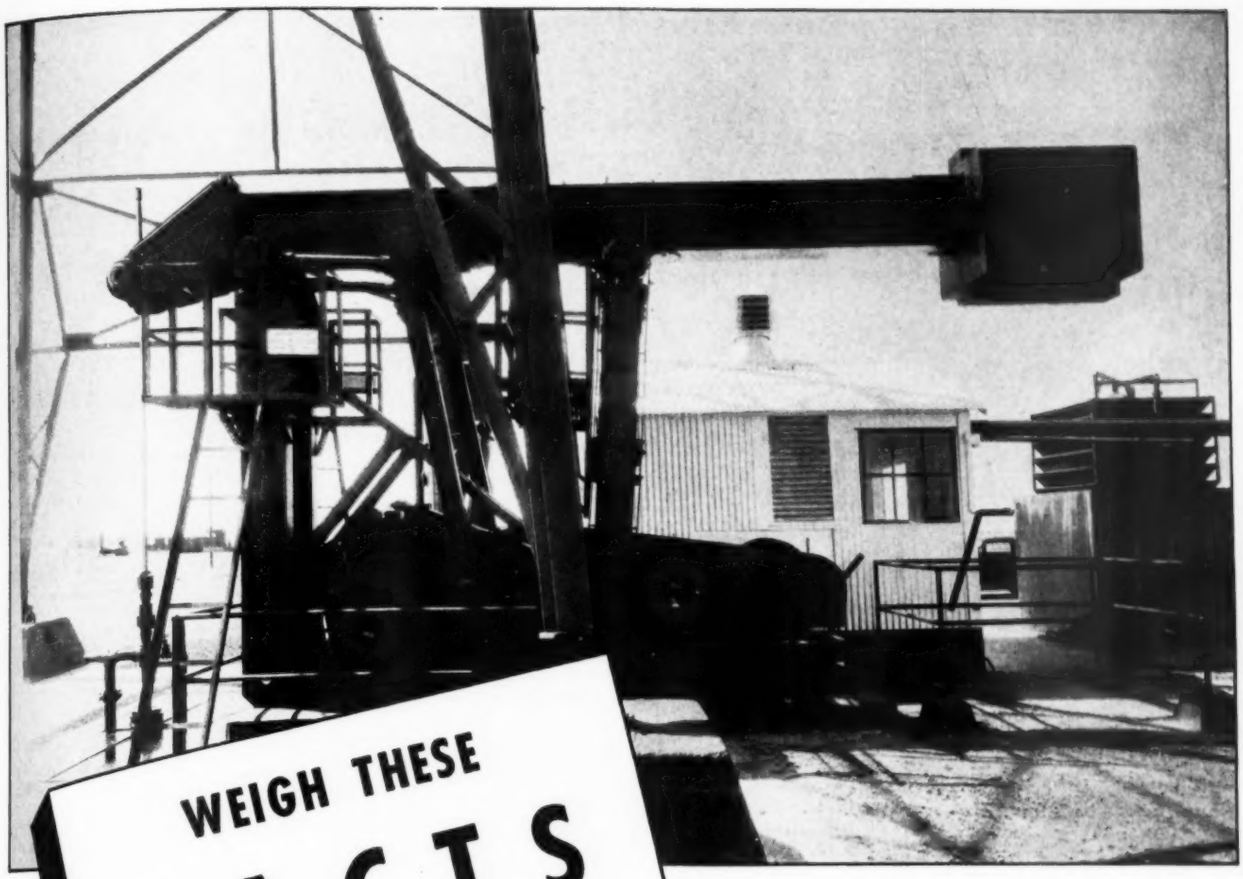
K. R. TEIS has resigned as chief production engineer for E. H. Moore, Inc., to enter private practice in Tulsa, Oklahoma, as a consulting petroleum engineer. His office is in the Thompson Building.

GLENN M. STEARNS has joined the teaching staff of the University of Oklahoma as assistant professor of petroleum engineering. He is a graduate of the school and has been in the employ of the Cities Service Oil Company, stationed in Kansas. He recently won a cash award for an article on "Arc Welded Casing in Oil Wells," a contest sponsored by the Lincoln Arc Welding Foundation.

GLENN M. STEARNS

W. H. BRATCHES, purchasing agent at Tulsa, Oklahoma, for the Shell Petroleum Corporation, has been transferred to the San Francisco, California, office of the company. **G. C. McLARON,** who has been his assistant, succeeds him at Tulsa.

LAWRENCE E. SMITH, who for 12 years has been in charge of editorial work in the Mid-Continent for the *National Petroleum News*, has joined the staff of the Independent Petroleum Association of America. He will assist in the work of the Petroleum Research Bureau program of that organization.



WEIGH THESE FACTS ABOUT PARKERSBURG PUMPING UNITS

- A size and type for almost every possible pumping condition.

- Designed for five to ten years of economical, dependable operation.

- Each type offers extra features and refinements that are not available on similar classes of pumping units.

- Backed by a warehouse and field engineering service that covers every active field in the country.

- Why not look into the foregoing facts before you "lay your money on the line" for any more pumping equipment. You can't go wrong and it may save you a lot of grief, time and money during the next few years. The Parkersburg representative in your field will be glad to give you more details and prices. His telephone number is listed on page 1613 of the 1938 Composite Catalog.

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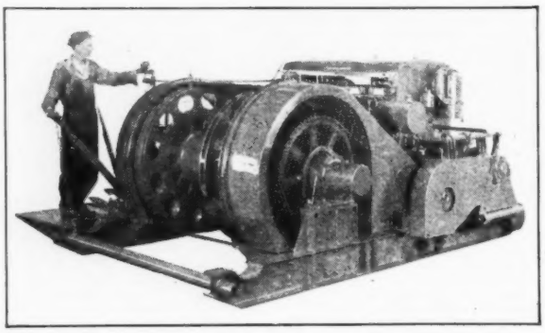
PARKERSBURG PUMPING UNITS

MACHINERY and EQUIPMENT

Isco Spudder Winch Has Rotary Attachment

THE New Isco Spudder Winch, Model 110, announced by International Supply Company, Tulsa, Oklahoma, offers great versatility and quick conversion for rotary drilling and well-servicing purposes. In just three hours the Isco winch can be converted into a rotary drawworks, having a capacity of 4000 ft. with 4-in. drill pipe, by adding the rotary drive sprocket and cathead assembly. In five hours the spudder attachment and upper drum assembly can be added to the unit for cable-tool drilling to a depth of 6000 feet.



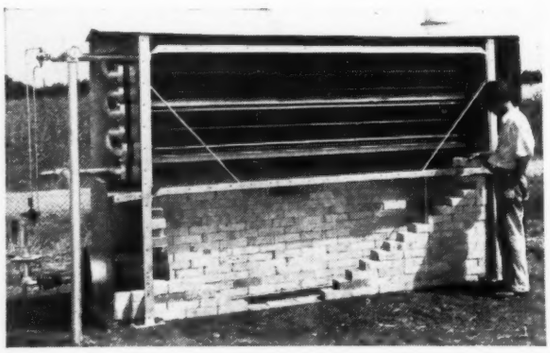
New ISCO Spudder Winch, Model 110
International Supply Company

In well-servicing, the Isco winch will handle rod and tubing jobs to depths of 10,000 ft. and clean-out work to 6000 feet. The unit can be installed on derrick floor or truck mounted for well-servicing.

All controls are assembled at the driller's position. Large brakes and drum assembly give considerable advantage over conventional equipment, the makers assert. The unit is portable, weighing 11,000 lb. without engine. Power is gas or Diesel to 150 hp. and the maximum torque is 550 ft-pounds. The spooling capacities of the upper drum are 6300 ft. of ¾-in line, 4500 ft. of ⅞-in. line, and 3400 ft. of 1-in. line. The lower drum handles 10,000 ft. of ¾-in. line, 7300 ft. of ⅞-in., and 5500 ft. of 1-in. line.

B. S. & B. Tubular Treating Heater

A TUBULAR treating unit has been announced by Black, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma, for heating corrosive water and sour crude under conditions that obtain in Michigan and West Texas.



Constructed like a refinery pipe still, the B. S. & B. Tubular Treating Heater is offered in four sizes having heating capacities for fluid volumes of 40 to 240 bbl. per hour.

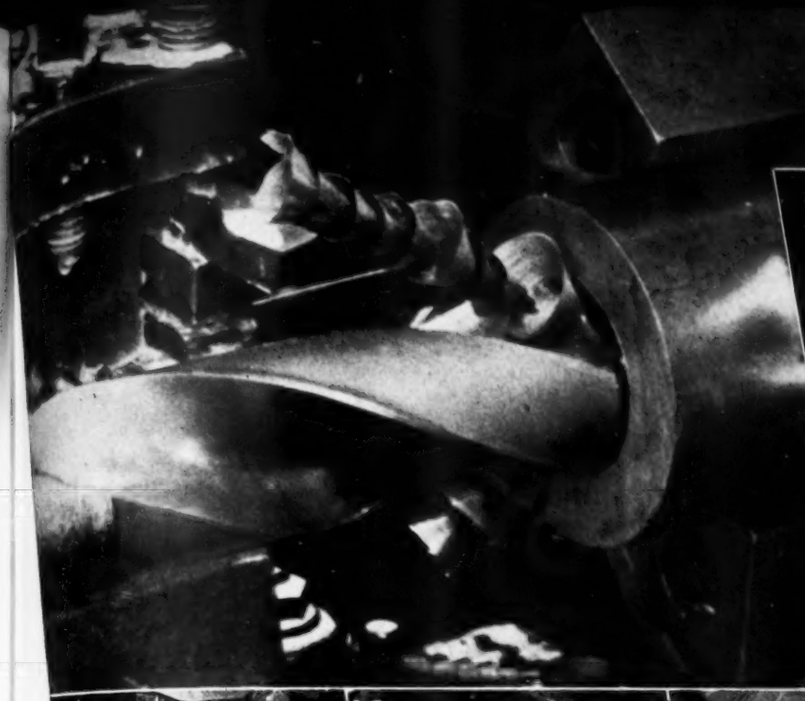
Three distinctive features of the unit are significant to operators in fields where conditions similar to those in Michigan obtain. Where gas is scarce the tubular heater is highly desirable because it has a high thermal efficiency. Most oil produced in Michigan must be treated, especially in cold weather, and heat will generally do this job. Owing to the ingenious arrangement and assembly of its parts, the B. S. & B. tubular heater can be easily repaired and new parts cheaply put in place, it is asserted. Regular 2-in. pipe is used for the tubes.

The unit is sheltered by sheet metal housing, is a straight tube heater, easy to clean or recondition, and inexpensive to renew, the manufacturers state.

Oil Center Tool Company Announces Pumping Head

A NEW O-C-T tubinghead for pumping wells, designated as type "T-22," is now being marketed through supply stores to the domestic trade and through Val R. Wittich, Jr., 30 Rockefeller Plaza, New York City, for export trade.

The light-weight, compact design of this new O-C-T head is illustrated in the accompanying sectional drawing. The body and packing nut are of malleable iron, and the slips are of heat-treated chrome-nickel steel. Only one outlet is provided in the body. Two Neoprene rings in the stuffing box above the slips are compressed by making up on the nut on top of the body. The nut is drilled in four positions to accommodate a rod for making up the threaded connection between the nut and body. The Neoprene packing rings, being impervious to oil and gas, will seldom require replacement. The stuffing box holds the slips securely in position in the tapered bowl.



2. Blanks for Axelson collars, cut to proper length, are drilled to semi-finish bore size on turret lathes.

AXELSON PUMP COLLARS lead a double LIFE!

THERE IS ONE AT THE TOP AND ONE AT THE BOTTOM OF EVERY PUMP

1. Blanks of cold rolled steel for Axelson pump collars are cut to length by automatic power hack saws.

3. After semi-finish boring, collars are then semi-finish counter-bored preparatory to finishing to size.

4. Collars are next counter-bored to finished diameter for jacket threads and checked for size.

There are some words that are never used in the Axelson factories. "Hurry" is one of them; "get-by" and "good enough" are others. Nothing is ever "good enough" in Axelson practice until it is the "best possible."

There is nothing better on earth than the solid cold rolled bar stock that Axelson uses for collars today. If there is anything better tomorrow, Axelson will have it. This is the policy that Axelson adopted forty-six years ago—it is the same policy that is still followed in Axelson plants today.

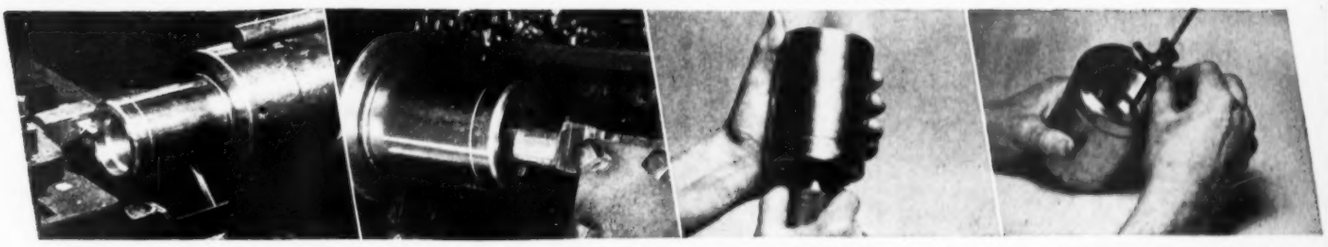
When you buy any Axelson product or part you get the customer benefits of this policy in honest materials and workmanship from which you profit in satisfaction and economy in service.

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

5. The face of the collars which clamps against the ends of the liners is finished to a smooth, flat surface.

6. Axelson multiple thread circular chasers are used to produce jacket threads in one end of the collars.

7. The operator gages each finished jacket thread for proper fit, after which inspector checks operator's gaging.



8. Collar is screwed on master chuck to be faced and radius machined on other end. Master chuck insures alignment of ends.

9. Next, tubing end is rough and finish bored. Axelson multiple thread circular chasers produce tubing threads.

10. Operator checks tubing threads after which the inspector verifies with plug gage that threads are correct.

11. Inspectors next give final check to other collar dimensions, i.e., length of threads, over-all length, etc.

12. Each collar is marked for identification with part number, size and other coding.

13. Axelson collars are stored in steel shelving after having been washed and coated with rust preventive solution.

AXELSON

DEEP WELL PLUNGER PUMPS
SUCKER RODS

Axelson Manufacturing Company, P. O. Box 98, Vernon Station, Los Angeles • St. Louis • 30 Church Street, New York • Tulsa *Mid-Continent and Eastern Distributor:* Frick-Reid Supply Corporation • *Rocky Mountain Distributor:* Great Northern Tool & Supply Company.

Darling Valve Introduces Unusual Cup Selector

THE Darling Valve and Manufacturing Company, manufacturers of Darvel and Darflex Cups, have just introduced a novel Cup Selector that permits the user to select the proper

sizes of any of the above composition cups for use in all makes of pumping equipment regularly used in the oil fields.

The Cup Selector is attractively made in dial form and carries the characteristic orange, blue, and green colors that for years have designated the Darcova, Darval, and Darflex valve cups.

Complete instructions for the use of the selector are shown on its face, and the simplicity with which the selector is operated is easily apparent.

As can been seen from the cut, the sizes of cups are listed consecutively around the outer edge of the center dial of the selector, and the names of various manufacturers and trade names of the pumps are listed in the panel at the bottom of the dial. It is merely necessary to set the size of the cup in the upper window and in the lower window read the names of the pumps on which this cup may be used. If it is desired to obtain the proper size of cup for use in any pump, the name and size of the pump is set in the lower window and the corresponding size of cup is read in the upper window.

These Cup Selectors will be supplied without charge by the Darling Valve and Manufacturing Company, Williamsport, Pennsylvania, upon written request. They should find a ready acceptance by operators, store men, warehousemen, and engineers, as the selector gives, in a concise form, complete information that heretofore has been available only in more complicated form.

Heavy-Duty Superior Sand Pump

A NEW, heavy-duty Superior Sand Pump is now being manufactured and sold by Oil Well Supply Company, Dallas, Texas. Increasing demand for Superior Sand Pumps where conditions are extremely severe led to the development of this new model. It is similar in general design and principle of operation to the regular type pump, but is equipped with a heavier tube and is constructed throughout for the most exacting service. The main advantages of the new pump are safety, dependability, convenience, and quick action.

The screw-type bottom bushing (3), which is riveted and welded to the seamless-steel tube, provides a strong threaded connection for the interchangeable bottoms. The sand pump bottom (4) gives best performance where sediment is loose. The chisel bottom (10) is used where it is necessary to break-up tightly packed sand. Both bottoms are easily and quickly dumped by merely pressing the trip latch (4-g) outward, thus releasing the complete valve assembly (4-b) and permitting it to swing downward on its pin. It is unnecessary to remove the bottom for either releasing or replacing the valve assembly.

The improved top (1-a), for years a popular feature of the regular type Superior Sand Pump, is also a part of the new heavy-duty pump. Its principal advantage is that it facilitates using only one line for both the sand pump and the cleaning-out tools; and it is unnecessary to cut this line when changing over. The improved top also eliminates fire hazard arising from babbitting the line in the plunger extension or rope socket, an operation frequently performed on the derrick floor.

The wire line for the Superior Sand Pump is permanently secured to the mandrel (2-h). Attaching the line to the pump is accomplished by removing the insert (1-d) from the improved top and the side piece (2-d) from the top of the plunger (2-a), placing the mandrel in the plunger extension, and then replacing the plunger side-piece and the top insert. The collar (1-f) locks the insert in the top.

Using a single line for both sand pump and cleaning-out tools is facilitated by the improved special rope socket (18), which takes the place of a conventional rope socket in the string of tools. It is of slotted construction at the top and has a recess or seat for the same mandrel (2-h) that is used for attaching the line to the Superior Sand Pump.

The new, heavy-duty Superior Sand Pump is fully described in "Oilwell" Bulletin No. 170-A.

Acid-Proof Cements

SINCE the comparatively recent development of acid-proof tile and brick in this country, (about 20 years ago) considerable progress has been made in the formulation and application of acid-proof cements. Producers of these special cements have striven to achieve a product scientifically dependable under varied and severe demands.

Some years ago, the Sauereisen Cements Company, Sharpsburg, Pennsylvania, developed and patented a new type of sodium silicate cement having quick-setting and chemical-hardening characteristics and designed to resist all acids, (except hydrofluoric), at all concentrations and at all temperatures to 2500 deg. fahrenheit. This cement was also compounded to be impervious to fire, oil, water, and such solvents as chlorine, bromine, iodine, and neutral salts. Since that time a careful study has been made of various industrial applications on pickling tanks, vats, floors, sewers, stacks, and glass blocks, and the following tables are compiled from actual results. The figures indicate the economies in time, labor, and material that may be obtained by the use of a cement specially designed for acid-proof construction. (Table 1)

The chemical constituents governing the setting time of the cement permit regulation of the working time by governing the temperature under which work is being done. Table 2 shows the relation of final setting time to the temperature.

Temperatures below 50 deg. fahr. and above 80 deg. fahr. are impracticable.

TABLE 1

BRICK

Acid-Proof Cement Required for 1/16-in. Joints

Size	*Number of sides Buttered*	*Brick per Sq. Yd.*	*Sq. Yd. per 1000 brick*	*Cement per brick*	*Cement per 1000 brick*
9 by 4½ by 2¼	4	31	32.1	.121 lb.	121 lb.
9 by 4½ by 2¼	5	31	32.1	.311 lb.	311 lb.
9 by 4½ by 2½	4	33	30.03	.145 lb.	145 lb.
9 by 4½ by 2½	5	33	30.03	.326 lb.	326 lb.
8 by 4 by 2¼	4	39	25.6	.119 lb.	119 lb.
8 by 4 by 2¼	5	39	25.6	.254 lb.	254 lb.

TILE

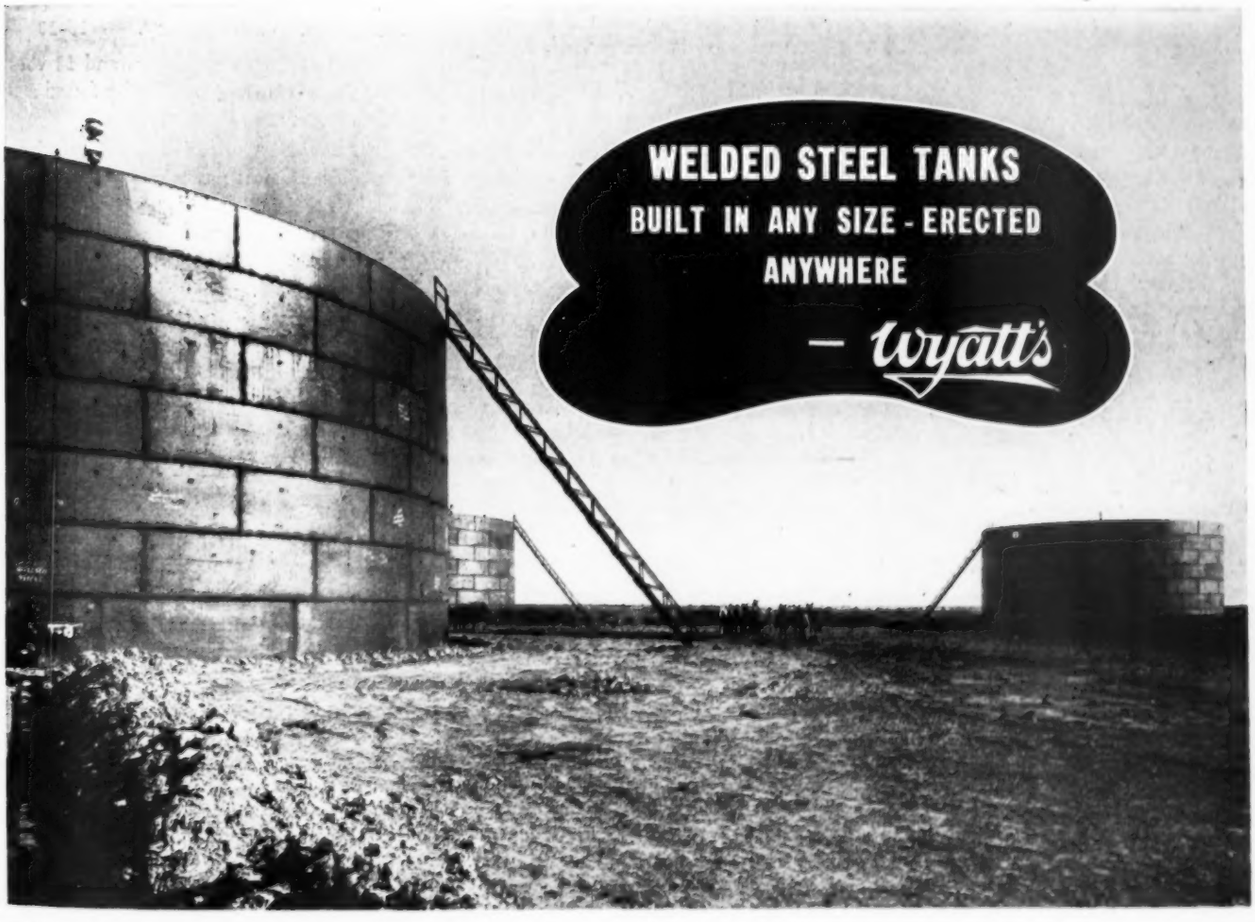
Acid-Proof Cement Required for 1/16-in. Joints

Size	*Number of sides Buttered*	*Tile per Sq. Yd.*	*Sq. Yd. per 1000 tile*	*Cement per tile*	*Cement per 1000 tile*
12 by 5 by 1¾	4	21	47.6	.133 lb.	133 lb.
12 by 5 by 1¾	5	21	47.6	.393 lb.	393 lb.
8 by 4⅞ by 1¾	4	32	31.2	.100 lb.	100 lb.
8 by 4⅞ by 1¾	5	32	31.2	.266 lb.	266 lb.

TABLE 2

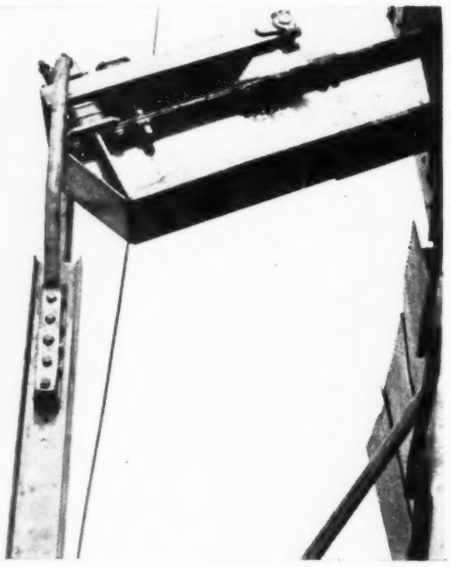
Temperature deg. fahr.	*Working time before initial set*	*Hardening time complete set*
50 to 60	1 hour	48 hours
60 to 70	¾ hour	36 hours
70 to 80	½ hour	24 hours

It should be noted that quantity figures are given for $\frac{1}{16}$-in. joints as joints of this thickness have been found to be ideal. Of course circumstances might warrant slightly thicker joints, but it should never be necessary to apply acid-proof cements in joints thicker than ⅛ in., except pointed joints, which may be $\frac{3}{16}$ inch.



Walking Beam Shock Absorbers

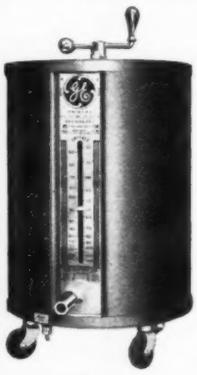
A WALKING beam shock absorber for National Drilling Machines has recently been placed on the market by The National Supply Company, Toledo, Ohio. This is designed to protect the machine from the shock of direct wireline drilling and to eliminate the necessity of a manila cracker.



The shock absorber is simple in construction and easily installed. It consists of a pitman bearing carried on four rubber cushions, which absorb the drilling shock, and a single cushion for taking the rebound. The amount of compression is adjustable by means of adjusting bolts.

General Electric A-C Arc Welder for Light-Gauge Work

A NEW 150-amp. a-c. arc welder of the transformer type has been developed by General Electric Company, Schenectady, New York, for low current welding with heavily coated a-c. arc-welding electrodes. Although chiefly intended for use on light-gauge metals, its wide welding range—35 to 180 amp.—permits its use on fairly heavy materials as well.



Use of equipment of this type reduces power costs approximately 50 percent as compared to the cost when welders of the rotating type are used, according to the manufacturer. In addition, it avoids troublesome arc blow, sometimes experienced with d-c. welders, thus reducing the number of rejects to a considerable extent and avoiding the necessity of reworking welds, it is asserted.

The new equipment is constructed with woven, spun-glass, fireproof insulation that prevents damage from heat on heavy overloads. Solidly-brazed internal connections eliminate the possibility of open circuits. Continuous, stepless current control is obtainable by means of a hand-crank. This arrangement gives accurate adjustment of the welding current to suit fine work. Adjustment can be obtained at any time without interrupting the arc or opening electrical connections.

A choice of two open-circuit voltages (80 and 100 volts) is provided for all types of a-c. electrodes. The welding lead can be quickly and easily connected to either tap by means of a taper-bored connector. A circular cover plate over the terminals prevents chance contact with the terminal (or terminals) not being used. Easy portability is provided by casters or by means of a hoist sling over the hand-crank.

The equipment meets the rigid requirements of the latest standards of Underwriters' Laboratories, Inc., and is listed under their re-examination service.

Development in Piston Ring Manufacture

C. LEE COOK Manufacturing Company, Louisville, Kentucky, announces a new development in the manufacture of piston rings. The products made by the new process are known as Cook's "Tinized" piston rings, as their wearing surfaces are electrically coated with a tin-base bearing metal. Otherwise the rings are the standard Cook graphitic iron piston rings. This new feature is asserted by the manufacture to safeguard against initial cylinder scuffing, provide double-quick seating, and reduce break-in running time and friction.

Copies of a new bulletin describing the product are available and will be sent free upon request to the manufacturer.

"Softweld," an Electrode for Cast Iron

"SOFTWELD," manufactured by The Lincoln Electric Company, Cleveland, Ohio, is a heavily coated shielded-arc electrode designed for depositing a soft machinable alloy on cast iron. It is used to correct machining errors, fill defects, and produce a very soft machinable drillable weld in grey cast iron.

The coating on this wire (a non-ferrous alloy) is designed to cause the weld to flow over and bond to the cast iron with a minimum of penetration or heating of the base metal.

"Softweld" operates best with d-c. negative polarity, although a-c. may be used.

Although a single layer deposit will be machinable in the weld metal, at least two layers should be deposited in order to obtain a soft fusion zone. The entire weld area may then be machined, sawed, drilled, and tapped without difficulty.

The current should be just high enough to obtain the necessary bond.

Hold a fairly long arc (approximately ⅛ in.) weaving the electrode slightly from side to side.

Size	*Current Range*	*Arc Voltage*
5/32 in.	70-130 amp.	16-20

An average of 90 amp. and 18 volts at the arc will generally be found satisfactory.

As localized heating of cast iron may cause it to crack, care should be taken to keep the casting from becoming too hot. Weld intermittently if necessary. Short beads (2-3 in.) are preferable.

Peen each bead after depositing. The very small amount of slag left on the bead may then be brushed off with a wire brush.

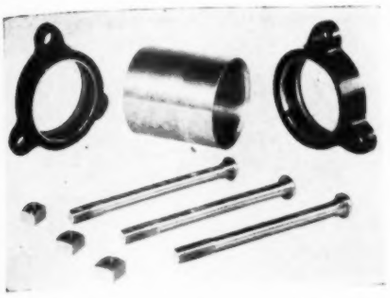
When correcting machining errors or filling sand holes or depressions, it is good practice to so prepare the work (by chipping, machining, or grinding) that the final machined surface will be ⅛ in. or more above the base of the bottom layer of weld metal.

When there is a large or deep area to be filled or when a strength weld is required, the most economical way to do the job is to use Ferroweld to within approximately ⅛ in. of the surface to be machined and then finish-off with two layers of "Softweld."

"Softweld" is made in $\frac{5}{32}$ in. by 16 in. only and packed in five-pound containers.

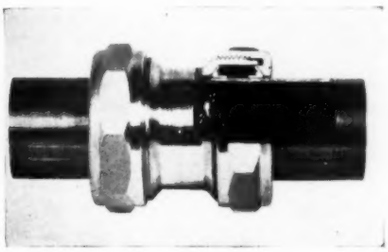
Meter Company Appointed Sole Distributor for Raybould Couplings

ANNOUNCEMENT has been made of the appointment of the Pittsburgh Equitable Meter Company as sole distributor for Raybould couplings



and fittings, manufactured by the Raybould Coupling Company, Meadville, Pennsylvania. Grover E. Seaberg, manager of the coupling and fitting division, will direct sales for the meter company.

The Raybould coupling is a patented article, said to provide an extremely simple and leak-proof method of joining plain-end pipe. It is described as consisting of two resilient compression rings, metal bushed at either end, en-



cased in two flanges or follower rings that bear against a center ring acting as a spacer between the flanges. The compression rings provide the sealing medium and the flanges sustain all the mechanical forces applied in tightening up the coupling. In sizes smaller than 3 in. the flanges consist of two compression nuts and the coupling is fastened by tightening these nuts on a threaded center ring. Larger sizes employ long track head bolts and nuts to draw up the two flanges.

Making a pipe joint with the Raybould coupling is said to be very rapid. The flanges on each end of the center ring are loosened but not removed and two sections of plain end pipe are then inserted until they encounter a tapered pipe stop situated equidistant from the ends of the coupling. The two flanges are then tightened and the job is done.

In the Raybould Coupling design the compression rings are metal bushed at each end to definitely confine and retain them in their prescribed area. It is said that a confined compression ring assures a continuous, leak-proof, and secure joint equal to the life of the pipe. To permit the metal bushing to close tightly around the outer wall of the pipe, a clearance slot has been provided. This slot not only takes up the allowed clearance over maximum pipe diameter, but also compensates for maximum and minimum tolerances in all pipe diameters.

Wash-Over Drill Pipe Cutter

ACME Oil Tool Company, Oklahoma City, Oklahoma, announce the introduction of the new wash-over McCullough drill pipe cutter. This new cutter is designed to permit the operator to wash-over stuck drill pipe and remove the cutter from the hole without damaging the cutter or making a cut except at the desired depth. This cutter will eliminate many unnecessary round trips, the manufacturers state. The fish is brought out in the cutter and wash pipe.

IT WILL PAY

EVERY BUILDER AND OPERATOR OF ENGINES AND COMPRESSORS TO SEND FOR THIS BULLETIN . .

It tells all about a radical advance in piston rings for industrial size engines and compressors—COOK'S "TINIZED" Rings—rings **with a permanently bonded coating of soft anti-friction metal**—rings that completely change the piston ring picture for both builders and operators from the standpoint of performance and economy. MAIL THE COUPON for your copy.

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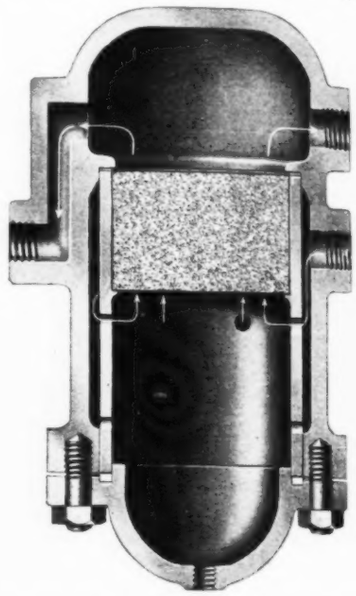
Flexarc Welding Cable

A FLEXARC Welding Cable that is flexible, durable, light in weight, and has positive insulation, applicable for field and shop use, is announced by Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. These cables comply in all respects with latest I.P.C.E.A. specifications for rubber-sheathed arc-welding cables.

The paper separator between the copper and rubber sheathing permits sliding action between the outside layer of wires and the rubber jacket. Also, the large number of fine copper wires composing the stranding provides for extreme flexibility. The protective jackets of these cables are of 60 percent rubber armor, built for hard usage under the most severe conditions and for long, reliable service with maximum safety.

Air and Gas Filters

NEW filters, designed to meet the increased demand for a highly efficient filtering device in gas and air lines, have been developed by the Fisher Governor Company, Marshalltown, Iowa. These new Fisher Types 360 and 361 filters remove foreign



matter and separate free moisture from the air and gas in pipe lines at a minimum friction loss. They protect expensive air tools, machines, instruments, and other devices against damage and costly service interruptions, at the same time guarding and improving the quality of the finished product.

Fisher filters utilize extremely hard aluminum oxide crystals bonded as a filter element. This especially manufactured filter element is both acid and heat resisting, and unusually strong. Gases pass through this porous filter with only slight loss due to friction.

The filters may be installed in either vertical or horizontal pipe lines with standard pipe fittings. They are unusually compact. Their advanced design separates free moisture before gases pass through the element. This reduces the load and results in longer service life and less frequent cleaning. Suitable drain cocks are provided. Flanged and bolted bottom castings permit easy, quick removal for cleaning.

The filter body is constructed of high-tensile iron, designed to give full capacity. These filters with screwed connections are available in sizes ¼ in. to 1¼ in. inclusive, and with flanged connections from 1½ in. to 2 inches.

Complete information about these filters is contained in Fisher Catalog I. A copy may be obtained upon request by writing the Fisher Governor Company, Marshalltown, Iowa.

SURWEL

GYROSCOPIC CLINOGRAPH

Sets Another Remarkable Record

The Superior Oil Company's deep well at Rio Bravo, California, was double surveyed when at a depth of 11,322 feet with the "SURWEL" Gyroscopic Clinograph attached to the drill pipe making the round trip in 5½ hours.

The Superior Oil—Geisenger No. 2 Rio Bravo, Kern Co., California

FROM THE LOG

In-run started at	9h 28m 00sec.
Bottom reached at	11h 41m 00sec.
Out-run completed at	2h 55m 00sec.
Total time for two surveys	5h 27m 00sec.
Closure between In and Out-run	6.1'
Maximum temperature recorded	218°F.

Records taken every 45 feet.

●

Sperry-Sun congratulates The Superior Oil Company and their California staff for successfully completing one of the fastest round trips ever made at such depth—a splendid performance!

SPERRY-SUN WELL SURVEYING COMPANY

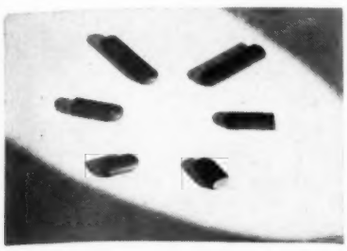
1608 Walnut Street, Philadelphia, Pa.

Tulsa, Oklahoma, 425 Petroleum Bldg. · Houston, Texas, 3118 Blodgett Ave. · Long Beach, Calif., 549 E. Bixby Road (1800 Block—Atlantic Ave.) · Bakersfield, Calif., c/o Elks Club, 17th and I Streets · Lafayette, La., Breaux Building, Cor. Lafayette & W. Vermilion Sts. · Corpus Christi, Texas, 332 N. Morningside Drive · Santa Barbara, Calif., 1409 E. Valley Road

(U. S. Patents 1,124,068; 1,812,994; 1,898,473; 1,959,141; 1,960,038; 2,006,556; 2,012,138; 2,012,152; 2,012,455; 2,012,456 and others pending)

Well Bit Inserts

HAYNES Stellite Company, Kokomo, Indiana, has developed a new design of Haystellite tungsten carbide inserts for hard-setting oil-well drilling and coring bits. They are now



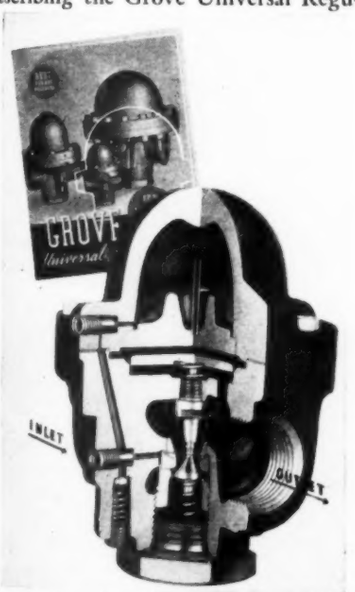
being manufactured in three new sizes, No. 14, No. 15, and No. 16. All have the same cross-section, but the three different lengths provide for all bit requirements.

The new inserts have a small flat area on one side that keeps them from rocking while the welding operator bonds them into the steel of the bit. Their design also allows them to be supported very rigidly by the steel surrounding them.

The new inserts have the same toughness as the older standard sizes of Haystellite inserts. They form an excellent bond with the tying-in steel, even stronger than previous designs, and resist shattering and breaking to a remarkable degree, the manufacturer asserts.

Grove Universal Regulators

THE Grove Regulator Company has released a new 24-page catalog describing the Grove Universal Regu-



lators. Complete data, sizes, and calculation charts are included to simplify selection for gas, oil, air, and steam operation. Instead of using springs, counterbalance, etc., to motivate the valve, the Grove design employs what is called the Grove-Boyle Power Chamber. It is asserted by the manufacturer that this method of pressure control is steadier and more accurate than other types. Several illustrations are used to clearly illustrate the interesting valve "snubbing" action created by the Grove-Boyle Power Chamber. The line includes all sizes to 6000 lb. per sq. in. for oil and gas and to 2000 lb. at 1000 deg. fahr. for steam. Copies of the catalog may be procured from the company's factory: 1729 Paplar Street, Oakland, California.

Couplings and Fittings for Gas Distribution Service

THE Norton-McMurray Manufacturing Company, Chicago, Illinois, has placed on the market a complete line of small couplings and fittings for gas distribution service. This line includes couplings in all sizes from ¾ in. to 2 in. in heavy 5 in. and 10 in. centers. Included are compression type ells and tees for gas distribution work.

The company claims several unusual features for its line including ease of assembly due to the fact that the pipe

Protection
IN THE DEEPEST
TOUGHEST WELLS
A BEAR
FOR WEAR
Grizzly Tubing Protectors keep the tubing string centered and prevent destructive wear on both casing and tubing in pumping service. By eliminating parted tubing due to excessive wear, they save thousands of dollars in equipment, time, labor and production. They are the best protection available against losses and off-production time in pumping wells. Descriptive Bulletin No. 14-OF mailed on request.
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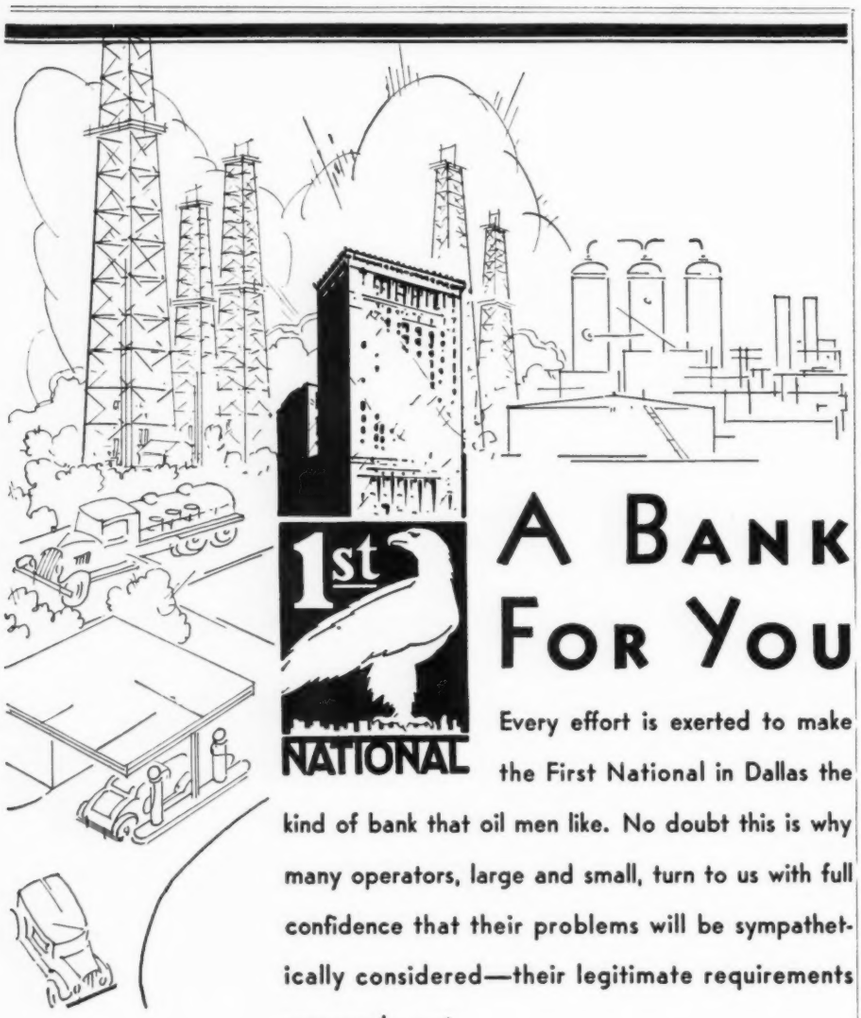
GRIZZLY
TUBING PROTECTORS

can be stabbed without removing the nuts on either the couplings or fittings. They claim the exclusive feature of offering their tees and ells with full coupling depth. The new line of adapters for tubing are said to be the first fittings of this kind offered to the industry with the coupling as part of the fitting. This eliminates the necessity of ordering tubes of specified length and eliminates also the necessity of flaring tubes on the job, it is asserted.

Cleaning Diesel Crankcases

AN improved method of cleaning Diesel engine crankcases is announced by Oakite Products, Inc., New York, New York. It is said the new method eliminates laborious, time-consuming scraping and wiping of surfaces. The method is based on the use of a recently developed cleaning material known as Oakite Composition No. 9, an oil-soluble emulsifier asserted to be especially designed to quickly and efficiently remove sludge, grease, and carbonized oil deposits. It is mixed with kerosene or light fuel oil. After the mixture has been sprayed on crankcase surfaces, it is allowed to soak, during which time grease and other accumulations are thoroughly softened and loosened. To complete the operation, deposits are flushed away with a high-pressure rinse.



1st NATIONAL

A BANK FOR YOU

Every effort is exerted to make the First National in Dallas the kind of bank that oil men like. No doubt this is why many operators, large and small, turn to us with full confidence that their problems will be sympathetically considered—their legitimate requirements generously met.

FIRST NATIONAL BANK

IN DALLAS MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

Linde Two-Stage Regulators

THE Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, New York, New York, announces three new regulators: the Purox Oxygen Regulator, Type R-201 (for ordinary welding and light

cutting); the Purox Oxygen Regulator, Type R-202 (for heavy-duty cutting); and the Purox Acetylene Regulator, Type R-203.

These regulators utilize the principle of two-stage regulation. A fixed "first stage" reduces the pressure of oxygen or acetylene from cylinder pressure to a moderate figure, below which it is regulated by the variable second stage of regulation. Stem-type valve mechanisms insure a uniform flow of oxygen and acetylene at the lower pressures at which the gases are used and in quantities sufficient for practically all welding and cutting operations, the manufacturers state.

The Monel metal valve stems are distinct from the diaphragms, thus eliminating the possibility of stem distortion due to diaphragm pull caused by leakage. Accurately machined guides assure correct alignment of the stems, it is stated. Heavy valve closing springs give positive seating action.

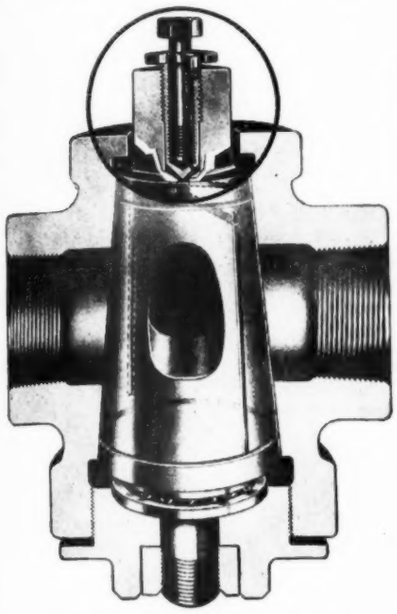
A striking feature of the new regulators is their attractive sturdy appearance. The first- and second-stage caps are bullet-shaped, giving the regulators a "streamlined" effect.

Mechanical Device for Plug Valve Lubrication

A NEW device to eliminate gas or fluid leakage during plug valve lubrication has been announced by MacClatchie Manufacturing Company, Compton, California. This exclusive MacClatchie feature, known as "Lubricheck," is standard equipment on all new MacClatchie "Hydro-Seal" plug valves, and the only mechanical means of plug valve lubrication on the market, according to the manufacturers. It is designed to give longer wearing life

to the valve through positive lubricating action and simple operation, and to eliminate the danger of regreasing plug valves under pressure.

"Lubricheck" consists essentially of a tapered seal that seats against the opening of the lubricating chamber and closes off gas or fluid when the lubricating screw is removed. The tapered seal is equipped with left-hand threads on its outer surface, and less than a quarter turn tightens the seal against the seat. As the right-hand lube screw, situated inside the seal, is re-



moved, the friction obtained serves to further tighten the seal against the seat, thus making possible a fluid-tight seal even under extremely high operating pressures, it is asserted. To lubricate, a MacClatchie grease stick is inserted, the lube screw replaced and tightened. A turn to the right automatically loosens the seal of the "Lubricheck" and opens the grease channels. Grease is then forced into the channels and lubricates the entire body and plug of the valve.

Simple construction of "Lubricheck" eliminates quick wearing parts that often do not thoroughly seal off the grease chamber and therefore allow line pressure to force the grease out of the valve when lubricating, it is stated. No sand or mud can interfere with proper operation of the "Lubricheck," and quick easy adjustment, or complete removal, of the lube screw can be accomplished with no gas or fluid leakage, it is said.

MacClatchie "Hydro-Seal" plug valves, equipped with "Lubricheck," are available in many sizes for field and pipe line operations, in screwed flanged, or union ends, and hand or gear operated.

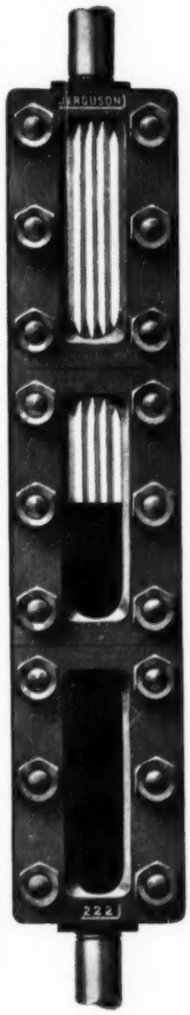
Salt Tablets for Men on Hot Jobs

MEDICAL authorities now say that anyone who works on a "hot job," anyone who exercises violently in hot weather or sweats profusely, should take salt tablets to replace salt lost by the human system in perspiration and prevent "heat sickness." For some time International Salt Company, Inc., Scranton, Pennsylvania, has supplied such tablets to industry. This company has now developed an attractive and convenient moulded plastic dispenser that makes it possible to distribute tablets at all drinking water locations where workers will use them. The dispenser is inexpensive.

JERGUSON

REFLEX GAGES

Standard for Over 30 Years



Employes like them because they are quickly and unmistakably read.

They are safe and dependable at high pressures and temperatures.

Ideal for gasoline, kerosene, oil, steam, no matter what the color of liquid—because . . .

Empty space appears
WHITE

Liquid level shows
BLACK

Jerguson Transparent (thru vision) Gages, for showing color and density of liquids, are just as accurate and as easy to read.

Furnished with or without valves for every type of service.

Jerguson Gages Are Best By Every Real Test

Send for Catalog

JERGUSON GAGE AND VALVE CO.
89 Fellsway Somerville, Massachusetts

Lincoln Foundation Awards

The Jury of Award of the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, after judging thousands of papers submitted in the $200,000 Award Program, found that savings to industry by arc welding claimed by authors of papers aggregate $1,600,000,000.

G. M. Stearns, district production engineer, Cities Service Oil Company, Russell, Kansas, received the largest award for a paper from the industry. His award was $2,543.88. His paper was "Arc Welded Well Casings."

An award of $712.28 in the petroleum machinery division went jointly to John F. Muller and G. C. Munoz, power transmission engineer and general manager, respectively, American Pulley Company, Philadelphia, Pennsylvania. Their paper was "Oil Pump Motor Base."

Award of $508.77 was received jointly by Phillip S. Ball and Justus O'Reilly, draftsman and assistant engineer, respectively, Skelly Oil Company, El Dorado, Kansas. Their paper was "Arc Welded Trays for High Pressure Bubble Tower."

Award of $305.26 went jointly to S. Wm. Riley and George Heinish, design engineer and chief engineer, respectively, Star Drilling Machine Company, Akron Ohio. The paper was "Arc Welding Advances the Art of Well Drilling."

Award of $203.51 went to A. M. Elder, engineer maintenance department, Gulf Refining Company, Toledo, Ohio, for his paper "Redesign of Coking Still Shell for Arc Welding."

Award of $152.63 went jointly to G. W. Woods and R. S. Grant, engineers, Hughes Tool Company, Houston, Texas, for their paper "Arc Welding Tool Joints Directly to Drill Pipe."

Honorable mention awards of $101.75 went to the following authors of papers on design of oil industry equipment: Fred C. King, Jr., draftsman, The National Supply Company, Torrance California; L. W. Mosley, owner, Baker Oil Company, Huntington Park, California; R. H. Biggs, Midland, Texas; Joseph W. Gasper, designer, Maine Machine Works, Ltd., Gardena, California; jointly to W. C. Russell and L. W. Stahl, superintendent, structural division, and chief engineer, mechanical division, Emsco Derrick and Equipment Company, Los Angeles, California, and Houston, Texas; and R. E. Hughes, district foreman, Standard Oil Company of Louisiana, Oxford, Louisiana.

Gordon S. Richmond Made General Sales Manager Hughes Tool Company

Appointment of Gordon S. Richmond as general sales manager has been

GORDON S. RICHMOND

announced by the Hughes Tool Company, Houston, Texas. Stanley P. Brown, who has been both vice-presi-

WORKING PARTS OPERATE IN OIL,

Eliminating

RUST AND WEAR

All internal parts of the Abercrombie Pressure Gauge operate in a bath of oil; the oil filled cast-aluminum case being filled with oil, and oil tight. Thus are rust and wear entirely prevented, and a longer life of accurate service assured.

This is only one of the numerous advantages offered by this entirely new gauge principle which has met with immediate acceptance in the oil industry.

Write for full details and prices.

FLUID-PISTON SLUSH PUMPS
ABERCROMBIE PUMP CO.
GULF BLDG. HOUSTON TEX.

OTIS
"Don't Kill Your Well"
Call OTIS

dent and general sales manager, has delegated the duties of general sales manager to Richmond. Brown remains active in every way, retaining the position of vice-president. Richmond has been associated with the Hughes Tool Company since 1929, going to that company as sales representative in the Houston area. Previously he had been with the Continental Supply Company. Starting in the oil business with Prairie Oil and Gas Company in Independence, Kansas, in 1919 he joined the Sinclair Oil and Gas Co., Houston, Texas. He is active in the Houston Chapter, American Petroleum Institute, Division of Production.

Walter Reid Passes Away

Walter Reid, 40, chairman of the board of the Southern Union Gas Company and several other companies, died of a heart attack at his home in Dallas, November 4.

WALTER REID

He was also chairman of the board of the New Mexico Eastern Gas Company, New Mexico Gas Company, and Southern Union Utilities Company, and a member of the American Society of Mechanical Engineers, American Gas Association, and Royal Society for the Encouragement of Arts, Manufactures and Commerce having headquarters in London.

He invented the Reid vapor-pressure apparatus to measure gas pressure.

Correction

An error appeared in Part IX of "Slide Rule Mechanics For Pipe Line Engineers," page 51, October issue of *The Petroleum Engineer*. Scale "B" should be "C", as the pressure varies as the square of the quantity flowing.

New Jarecki Store at St. Elmo, Illinois

The Jarecki Manufacturing Company, Erie, Pennsylvania, has opened a new oil-country store at St. Elmo, Illinois. Personnel of the new store includes: Ralph R. Jones, store manager; Robert L. Brannon; Curtis A. Spangler; John W. Sydnor; and Walter E. Montgomery, Jr.

From this store Jarecki is distributing a complete line of oil-field supplies, as well as its own line of valves, fittings, and oil-field specialties.

Lucey Executive Joins Frick Reid Supply

John A. Chapman has resigned as general manager of the Lucey Products Corporation to become associated with the Frick Reid Supply Corporation at Tulsa, Oklahoma, specializing in rotary drilling equipment. Chapman is widely known in the oil industry, having been associated with Lucey since 1930.

ANY ENGINEER...

. . . knows that any group of men devoting nearly two decades of research and manufacturing experience to pumping equipment should build a darned good unit.

JENSEN BROTHERS MANUFACTURING CO.

. . . . . *Coffeyville, Kansas*

And JENSEN BROTHERS do. The JENSEN JACK is absolutely unrivaled for economical installation and operation. If you haven't considered it carefully—well, you should.

EXPORT OFFICE...136 LIBERTY STREET • NEW YORK, N. Y.

LINK-BELT

VIBRATING SCREEN

for Reconditioning Rotary Mud

● The Link-Belt Screen is recognized as the most efficient and lowest cost method of effectively reconditioning rotary mud. Its many exclusive features, such as fine mesh stainless steel screen cloth, rubber cushioned; adjustable feed; enclosed vibrator unit; unitized collecting tank; self-contained drive, etc., have made it the screen preferred by most drilling contractors and operators. Made in two sizes for shallow, medium and deep well drilling. Send for Folder No. 1772.

Link-Belt Company, Philadelphia, Houston, Tulsa, Dallas, Los Angeles, Indianapolis, Chicago, New York. Distributors in all fields. 7842

LINK-BELT *Vibrating* SCREEN

6 REASONS

WHY CONCERNS LIKE YOURS FIND OAKITE CLEANING SAVES MONEY

FOR 29 YEARS Oakite materials have pioneered the trend to faster, more thorough, economical cleaning.

YEAR AFTER YEAR the choice of the leaders in the oil industry has been Oakite materials because they put essential cleaning operations on a sound basis of efficiency and economy.

THOROUGH RESULTS are one reason for this economy and efficiency. Every Oakite material is compounded to provide energetic, time and effort-saving cleaning.

SAFETY is still another important feature. Oakite materials are non-inflammable. They will not damage the surfaces they clean.

LOW COST cleaning with Oakite materials is due to their concentrated strength . . . their longer life in service.

FOR EVERY JOB. Put Oakite cleaning to work for you cleaning coolers, heat exchangers, all process equipment . . . cleaning or stripping storage tanks, trucks, cars . . . cleaning barrels, drums, floors . . . and, in fact, on every cleaning job in your plant.

Put YOUR problem up to Oakite cleaning. Write.

Manufactured only by
OAKITE PRODUCTS, INC., 48 Thames St., NEW YORK, N. Y.
Branch Offices and Representatives in all Principal Cities of the U. S.

OAKITE
SPECIALIZED INDUSTRIAL CLEANING MATERIALS & METHODS

TRADE LITERATURE

AN UNUSUALLY ATTRACTIVE FOLDER is being mailed to members of the oil industry by the Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania, announcing the completion of their latest unit, the Gilmore Wire Rope Division at Muncy, Pennsylvania, which is now in full operation. Robert Gilmore, who has spent the major part of his business life in the development and manufacture of wire rope, is general manager of the new division.

The folder, which contains numerous photographs showing various phases in the manufacture of wire rope at the plant, also presents some of the company's aims with respect to wire rope making. One of these is the matter of precision. They are manufacturing precision ropes from $\frac{1}{16}$ in. to $4\frac{1}{2}$ in. diameter, and are providing precision in wire sizes and lays with a tolerance as close as 1/1000 of an inch. A positive lubricating element also has been developed, which the manufacturer states will increase the life of the wire rope.

Copies of the folder are being sent to interested parties upon request.

●

THE RIDGE TOOL COMPANY, Elyria, Ohio, has issued a new bulletin that gives complete information on its new No. 65R and 85R series pipe threaders, having all-steel and malleable-alloy construction. These new tools thread four sizes of pipe with one set of chasers, offer a choice of two new workholders, a cam and plate type. This literature also describes the new No. 1R series poster pipe threaders having all-steel and malleable-alloy construction; four sets of chasers; full floating, separately replaceable posts, choice of cam or plate type workholders. Chaser dies fit any make of poster threader and all dies of the same number are interchangeable with similar number of any other Ridgid Poster set.

●

AN ATTRACTIVE AND COLORFUL NEW CATALOG, describing in detail pump governors, regulators, liquid level controllers, valves, traps, and strainers manufactured by the Fisher Governor Company, Marshalltown, Iowa, is just off the press. The catalog (No. 35) describes and illustrates 183 different automatic controls and steam specialties. It contains more than 73 installation photographs and diagrams. Dimensions, working pressures, and prices are given in complete detail.

A copy of this catalog may be obtained by writing the Fisher Governor Company, Marshalltown, Iowa.

●

PROCEDURES FOR PRODUCING ALL TYPES OF WELDS in mild steel, for welding all metals used to any extent industrially, and for applying surfacing metal to meet any type of wear-action in service, are given in a new bulletin just released by The Lincoln Electric Company, Cleveland, Ohio.

Of value to all users of welding, the bulletin is available on request from The Lincoln Electric Company, Cleveland, Ohio. In writing for it, ask for "Bulletin 401-A."

Baroid Constructs New Laboratory Building

The construction of a new laboratory building adjoining its general plant at 837 Jackson Street, Los Angeles, California, affords the Baroid Sales Department the opportunity to further its research and development on drilling fluids. The addition includes a research laboratory, a mechanical testing laboratory, a testing-equipment display room, and also houses various departmental offices, besides a mud-sample room, duplicating room, and photographic laboratory.

Elaborate Exhibits Planned for Houston Show

According to Ed Lenzner, general manager of the Oil-World Exposition, contracts for space already signed indicate that the 1939 Oil Show in Houston will be considerably larger than the one held in 1937. Approximately the same number of exhibitors that displayed equipment in the previous show have taken space at this early date although the Exposition will not be held until April 24 to 29, inclusive. Lenzner states, moreover, that increased size is not the only factor to make the 1939 show a greater event. Many exhibitors have indicated the extent of their plans for the 1939 Exposition, and not only is it evident that the appearance and decorations of the displays are to be much more elaborate but that greater effort is to be put into showing equipment most advantageously for the benefit of visiting oil men.

ED LENZNER

As a further means of presenting engineering data to the industry and giving the exhibitor a better opportunity for showing field application, continuous moving pictures of tools and machinery in operation will be given during the entire week. These showings will be open to all visitors at the Oil Show and will be given in a room adjacent to the exhibiting space in the Coliseum. The reels shown will be in addition to any presented at the individual booths of the exhibitors.

An added feature of this moving picture presentation will be that all reels will be scheduled for specified hours during the day. This will enable any exhibitor having pictures to be run off to invite oil men to see his particular reels. Field and plant operations to be covered will include drilling, production, pipe line, natural gasoline manufacture, refining, and transportation. Manufacturing processes of an unusual nature will also be portrayed and laboratory work relative to both field operations and equipment development will be shown to give the visitor an idea of the type of research that is being done to advance field methods and equipment design.

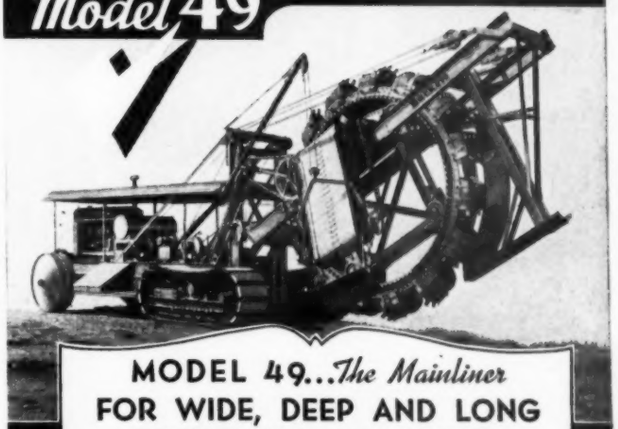
Pictures of a more general nature, showing the use and application of American equipment to foreign operations, will give the visitor an idea as to the widespread distribution of American tools and machinery throughout the world.

Pittsburgh Equitable-Merco Nordstrom District Managers' Meeting

The annual meeting of the district managers of the Pittsburgh Equitable Meter Company and the Merco Nordstrom Valve Company was held recently at the main offices in Pittsburgh, Pennsylvania. Colonel W. F. Rockwell, president of the two companies, presided over the sessions. District managers attending were C. R. Zeskey, Kansas City, Missouri; M. J. Harper, New York City; F. G. Swaffield, Columbia, South Carolina; A. J. Kerr, Tulsa, Oklahoma; Z. A. Stanfield, Memphis, Tennessee; D. E. Foster, Pittsburgh; C. F. Thomas, Buffalo, New York; H. Boezinger, Los Angeles, California; A. L. Fritchey, Des Moines, Iowa; P. C. Kreuch, Chicago, Illinois; and W. H. Davis, Oakland, California.

Buckeye

Model 49



MODEL 49...*The Mainliner*

FOR WIDE, DEEP AND LONG TRENCHING ANYWHERE

BIG pipeline trench—to 43" wide and 8' deep, moves steadily along when Buckeye Model 49 starts down the line. No soil condition short of solid rock can stop the powerful march of this machine. Choice of a wide range of digging speeds enables the operator to speed up where going is easy, and gives him perfect mastery of the tough spots as well. Transmission drives for all operations are fully enclosed. Here is streamlined performance — with profit for you.

Originators of the Wheel type Ditcher

MODEL 12 . . . *The Pipeliner*

Whether you start across country on a hundred mile stretch of hard digging or have an easy job you want to finish up in one day, the characteristic Buckeye dependability of the Model 12 saves you time and money. Handles trench from 14½" to 24" wide, 5½' deep. A real pipeliner, with everything it takes to do the job right.

THE BUCKEYE TRACTION DITCHER COMPANY
FINDLAY, OHIO

Send complete information on the { "Mainliner" Model 49 Ditcher ☐ / "Pipeliner" Model 12 Ditcher ☐

Name_____

Address_____

City_____ State_____

Rugged new RIDGID No. 65-R All-Steel-Malleable-Alloy Die Stock, *with drop-forged hardened tool-steel cam plate, Threads 4 sizes of pipe with 1 set of chaser dies.* Your choice of 2 new mistake-proof workholders.

New strength and durability throughout. Quick automatic setting to size saves time and loss of chasers. Two speedy workholders, both practically automatic—no bushings. A modern super-efficient tool you'll take workmanlike pride in. Buy it—for quicker easier better threading at lower cost. Ask your Supply House.

New RIDGID No. 65-RP with plate type workholder. ←

→ *New RIDGID No. 65-RC with cam type workholder.*

THE RIDGE TOOL CO., ELYRIA, O.

No more pipe wrench housing repairs

RIDGID housing guaranteed not to break or warp —or we replace it Free.

RIDGID PIPE TOOLS

Trade Personals

ANDREW WATSON of the Tretolite Company has been transferred to Tyler, Texas, his position with the company being the same as it has been at Ellinwood, Kansas.

C. P. PARSONS, vice-president of the Halliburton Oil Well Cementing Company, discussed "Squeezing Cement into Permeable Formations" at the November 3 meeting and luncheon of the Houston Geological Society.

R. L. (BOB) BOTHWELL has been appointed oil country representative in the California fields for Thermoid Rubber Division of Thermoid Company, Trenton, New Jersey. Bothwell has been connected with the oil industry since 1918 and for the last three years has traveled the California area. He will sell the full line of Thermoid products for the oil field, including flat pumping belts, multiple V-belts, rotary hose, slush pump hose, oil suction and discharge hose, and miscellaneous types of hose, packings, and brake linings.

J. N. WALKER has been elected vice-president of Oxweld Acetylene Company, a unit of Union Carbide and Carbon Corporation, New York. Walker has been general sales manager of The Linde Air Products Company, also a unit of Union Carbide and Carbon Corporation. T. D. CARTLEDGE, formerly assistant general sales manager, has been appointed general sales manager of the latter company.

John W. Yerger Joins Kibele Staff

John W. Yerger, Houston, Texas, on November 1 became sales representative in Southern Louisiana, Texas Gulf Coast, and Southwest Texas for the Kibele Manufacturing Company, Dallas. Yerger will sell Kibele's complete line of boiler-feed pump pistons, swabs, tubing catchers, and valve-in-head packers.

JOHN W. YERGER

The new Kibele representative for a number of years represented the Well Equipment Corporation of Houston in Southern Louisiana and the Gulf Coast. He is a native of Vicksburg, Mississippi, attended Louisiana State University where he took a course in mechanical engineering, and has lived in Houston for the last ten years. He will continue to make his headquarters in the latter city.

Statement of the Ownership Management, etc., of THE PETROLEUM ENGINEER October 1, 1938

(This statement is published in compliance with the Act of August 24, 1912.)

Published at Dallas, Texas, monthly August through June, semi-monthly in July.

Publisher: The Petroleum Engineer Publishing Co., Dallas, Texas.

President and General Manager: Clarence Morris, Dallas, Texas.

Editor: K. C. Sclater, Dallas, Texas.

Stockholders holding 1 per cent or more of total amount of stock: C. R. Barrett, W. T. Bryan, W. L. Love, Clarence Morris, and K. C. Sclater, Dallas, Texas; J. L. Dwyer, T. J. Crowley, and Mrs. J. H. Dameron, of Tulsa, Oklahoma.

Known bondholders, mortgagees and other security holders holding 1 percent or more of the total amount of bonds, mortgages or other securities: Johnston Printing and Advertising Co., Olmsted-Kirk Co., A Zeese Engraving Co., Jaggars-Chiles-Stovall, Inc., Tower Corporation, F. H. Penn, Texas Power & Light Co., Dallas Clearing House Association, Dallas Gas Co., E. R. Brown, Dallas Power & Light Co., Southwestern Bell Telephone Co., F. R. Schneider, Trustee, F. V. Faulkner, A. Harris & Co., Gulf Insurance Co., Higginbotham-Bailey-Logan Co., Adolphus Hotel, The Scarbellkopf Co., Industrial Dallas, Inc., Von Hoffman Press.

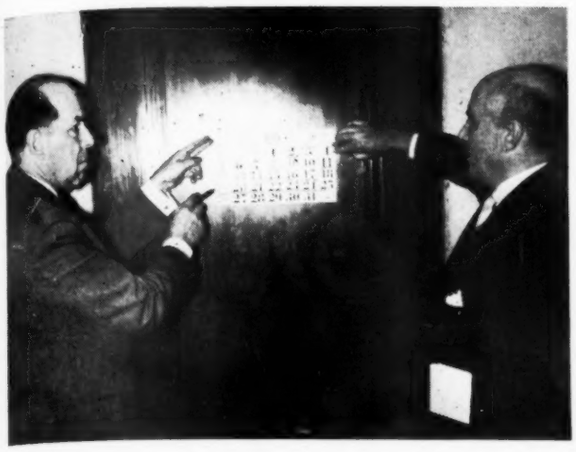
W. T. Bryan, Secretary-Treasurer.

Sworn to and subscribed before me this 30th day of September, 1938.

Lillian F. Haddock, Notary Public.

(My commission expires June, 1939.)

International Petroleum Exposition Dates Set



The 1940 International Petroleum Exposition will be held May 18 to 25, President W. G. Skelly announced at Tulsa during the Independent Petroleum Association of America meeting. In the picture are Skelly and Wm. B. Way, general manager, marking the dates on a 1940 calendar.

Rex Parks to Patterson-Ballagh Staff

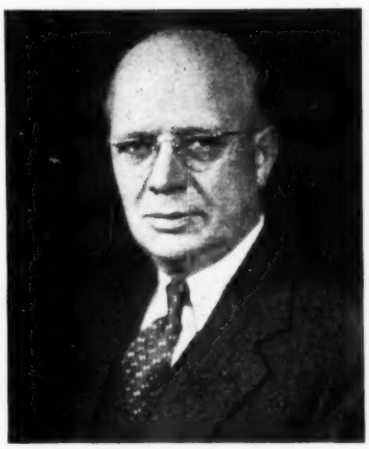
Patterson-Ballagh Corporation announces the appointment of Rex Parks as assistant to J. M. "Skeet" O'Melveny, sales manager in the Gulf Coast and Mid-Continent area. Parks is well qualified for the position, having had several years' experience both in the drilling and supply end of the oil business. He has been a driller recently for Loffland Brothers in Kansas and the Gulf Coast, and has also been connected with the J. E. Mabee Drilling Company for several years as roughneck and driller. He joined the Bovaird Supply Company as field salesman in Oklahoma, later going with the Chicago Pneumatic Tool Company as district manager. He recently left the Green Head Bit and Supply Company to join the Patterson-Ballagh Corporation. Parks will make his headquarters in Houston, Texas, and will cover the Gulf Coast and Mid-Continent area.

REX PARKS

C. E. Johnson, New IHC Assistant Advertising Manager

Carroll E. Johnson has been appointed assistant advertising manager of the International Harvester Company. He succeeds A. C. Seyfarth, whose promotion to advertising manager was announced recently.

Johnson joined the advertising department in May, 1903, after several years of retail selling experience. In 1909 he joined the copy department and wrote general copy until July, 1915, when he was made copy chief.



CARROLL E. JOHNSON

Reduce your pumping costs

One of the most dependable ways in which to reduce pumping costs is to install

B-M-W Admore Insert Pump Anchors

This useful device:

1. Saves TIME by eliminating the necessity of pulling tubing, and by simplifying pumping operations.
2. Saves POWER where the fluid level is high and the well can be pumped above bottom.
3. Saves the FIRST COST of other seating means such as working barrels, seating nipples, or mechanical shoes. And where the fluid level is high there is a further saving in sucker rods and other equipment.

Screws directly onto the pump. Replaces the conventional cup or mechanical hold-down. Pump is operated in the usual way with no special care required. When the desired setting position is reached the slips are tripped by lifting and turning the rods, and the packer is set by the weight of the rods. Complete data on request. See our advertisement in the "Composite Catalog."

SUPPLY STORES SELL THEM

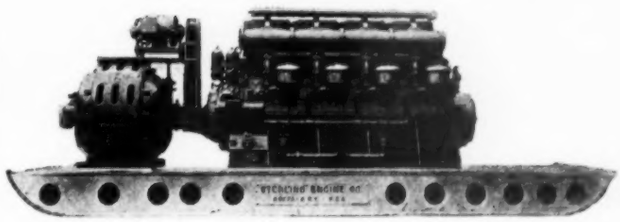
Also such other B-M-W Products as: ● NEILSON TOOLS (Safety Sucker Rod Hooks; Tubing Hooks, Rod Elevators, Sucker Rod Sockets, etc.); ● BALLS and SEATS (made for every pumping service); ● ADMORE Liner Barrels; ● TEX TYPE Plunger Fittings and Valves; and ● COLLINS Belt Clamps.

BRADFORD MOTOR WORKS INC.

OIL WELL SUPPLIES

BRADFORD, PA. — TULSA, OKLA.

LEADING ENGINE BUILDERS CHOOSE **ENSIGN**

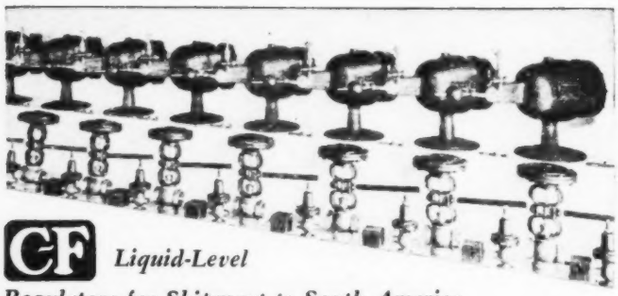


STERLING Straight 8 Skid Engine, direct connected to electric generator, used for portable oil well drilling. This power unit operates on Natural Gas with four ENSIGN Carburetors.

ENSIGN Gas, Combination Gas and Gasoline, and Butane Carburetors are standard equipment on Sterling Engines. In fact, these Carburetors made by ENSIGN, are standard equipment with more than ninety percent of the country's leading engine manufacturers. Such popularity is a tribute to the excellence of ENSIGN products.

ENSIGN Gas, Combination Gas and Gasoline, and Butane Carburetors help assure dependable engine performance at minimum operating cost.

ENSIGN



CF *Liquid-Level*

Regulators for Shipment to South America

Customer in Peru Orders TEN MORE

Four orders, each for ten C-F Vigilant Liquid-Level Regulators of the same type, have come from a single user in Peru. Our illustration shows the most recent lot ready for shipment. Regulators of this type maintain liquid levels constant in cracking stills, bubble towers, vaporizers, and the like. Ask for Bulletin 3113. Catalog of C-F Regulators for all requirements of pressure control also gladly sent on request.

The
CHAPLIN - FULTON
MANUFACTURING COMPANY
28-40 Penn Ave. Pittsburgh, Pa.

SUBSCRIPTION ORDER FORM

THE PETROLEUM ENGINEER,
Box 1589, Dallas, Texas.

(Enter) (Renew) my subscription for one year. My check in the amount of $2.00 is enclosed.

*Name*_____

*Company*_____

*Position*_____

*Home Address*_____

*Office Address*_____

*City*_____ *State*_____

H. L. McQuiston Becomes Lucey Special Representative

H. L. McQuiston, for several years division superintendent for Phillips Petroleum Company, has joined the organization of Lucey Products Corporation, Tulsa, Oklahoma, according to Franklin E. Bernsen, Lucey president. McQuiston, who has more recently been operating as an independent producer in the Gulf Coast area, becomes special representative of the Lucey firm with headquarters at Fairfield, Illinois.

H. L. McQUISTON

McQuiston joined the Phillips Petroleum Company staff at the time of the merger with Independent Oil and Gas Company, and for a period was division superintendent at Kansas City, later had his headquarters at Wichita, then moved to Oklahoma City five years ago to take charge of the central division. For two and one-half years he served as general superintendent for the Independent Oil and Gas Company under the management of R. B. Pringle.

BJ Has Representative at Kansas City

WENDEL CARLSON

The Pump Division of Byron Jackson Company now has a resident representative in Kansas City, Missouri, in the person of Wendel Carlson.

Carlson, who has had several years' experience at the Byron Jackson factories, will spread his activities over the petroleum and general industrial fields, and will render agricultural irrigation service. Although for convenience of the trade his residence has been established in Kansas City, his business address is Byron Jackson Co., Fort Worth, Texas.

Kyner-Long Corporation New Firm

Jon R. Long, president of Jon R. Long, Manufacturer, Ft. Worth, Texas, and Bob Kyner, chief engineer of the Gas-Lift Sales Corporation, have formed a company for the manufacture, development, and sales of gas-lift equipment. The new company is known as the Kyner-Long Corporation. At the present time three types of gas-lift valves are being manufactured.

Jon R. Long, Manufacturer, will continue to manufacture and sell pumping equipment.

Book Reviews

Petroleum Development and Technology—1938. Petroleum Division, A.I.M.E. Published as Volume 127 of Transactions of the American Institute of Mining and Metallurgical Engineers. Contains important papers presented before the Division at meetings held at Los Angeles, October 1, 1937; Oklahoma City, October 7-9, 1937, and New York, February 14-18, 1938. 733 pp. Price, $5.00.

The chapter on production engineering covers well spacing, gas caps, excessive pressures and their variation in the Gulf Coast, pressure-drilling operations, and the desalting of crude oils.

Engineering research data are presented on a number of diversified subjects, among which are effects of pressure on viscosity of gases, pressure distribution in reservoirs, relation of gas-well spacing to ultimate recovery and technical discussions on vaporization equilibrium constants, calculation of equilibria in hydrocarbon mixtures, and behavior of contents of high-pressure reservoirs. Connate water is discussed in two papers and the characteristics of drilling mud in three.

In a chapter on petroleum economics an equilibrium theory of proration is advanced, and uneconomic uses of petroleum and the market behavior of oil shares are discussed. The world consumption of petroleum products and the use of these products for military purposes are tabulated.

The annual production data for domestic and foreign fields include considerable operating and geological information on many of the areas covered. The book ends with a short review of refining engineering.

* * *

Handbook of Chemistry and Physics. Published by Chemical Rubber Publishing Company, Cleveland, Ohio, 22nd Ed., 1937, 2069 pp. Price $6.

This standard reference work has again been revised and enlarged. This edition contains about 50 pages more than the previous one, representing several new tables and the expansion of some already included. Actually even more new material is included, for some sections have been rearranged to present the same data in more compact form. The data on gravimetric factors have been revised to conform to the 1936 atomic weights. The usefulness of this volume to workers in every branch of industry has thus been still further increased.

On Trip for Security

L. G. "PAT" ROBINSON

L. G. "Pat" Robinson, formerly division manager of the San Joaquin Valley for Security Engineering Company, Inc., Whittier, California, is taking an extended trip throughout Illinois, Oklahoma, and Texas in the interests of his company.

H. F. Sutton, a member of the Security sales department for the last five years, will be transferred to Houston as division manager there.

H. E. Thompson has joined Security's sales department at Whittier as contact man.

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A Decimal System for Classifying Data Pertaining to the Petroleum Industry

By LESTER C. UREN*

TEN years have elapsed since the publication of the first edition of the "Decimal Classification" by the National Petroleum Publishing Company. During the interim, many persons have found the system useful in meeting their filing problems. The rapidly expanding volume and variety of petroleum industry literature of recent years has made it increasingly necessary that the student of the industry adopt some systematic method of arranging and classifying his material.

Since the inception of *The Petroleum Engineer* the editors have striven to present and arrange the material printed in its pages to facilitate orderly clipping and filing in accordance with the Uren Decimal Classification. It therefore seems appropriate that this second edition of the Classification should first appear in the pages of *The Petroleum Engineer.*

This second edition represents a considerable expansion of the original edition. Many new items have been inserted and numbers assigned that will, it is hoped, make the Classification of greater convenience to its users. This has been accomplished entirely within the framework of the 1928 edition, so that in adopting the new edition, those who have previously used it need anticipate no rearrangement of material previously filed. Because of its length, this revised edition of the Classification will be printed in several successive issues of *The Petroleum Engineer.* The current issue presents only introductory material, in which a broad outline of the general plan of the Classification is given, together with suggestions for its use in filing different types of material. Later issues will present more detailed lists of petroleum industry topics with their assigned classification numbers. After the detailed subject classification has been completed, an alphabetical arrangement of the same topics will be printed.

The writer and *The Petroleum Engineer* are indebted to the National Petroleum Publishing Company, publishers of *National Petroleum News* and owners of the coypright on the first edition of the Classification, for permission to publish this revised second edition. This permission has been granted as a service to those engaged in the petroleum industry, in the interests of more widespread use of the Classification to encourage systematic filing and orderly arrangement of material in publications serving the petroleum industry.

*Professor of Petroleum Engineering, University of California.

Explanation of the Decimal System of Classification

Systematic filing and indexing of technical papers, reports, notes, pamphlets, catalogs, clippings, maps, drawings, etc., is a problem that concerns every engineer and is a matter of importance in every oil company office. To those who use such material, the development of a suitable system of classification to facilitate orderly filing is a practical necessity.

Much useful material is buried in filing cabinets or piled on shelves or in cupboards, often with little or no pretense at systematic arrangement. When some particular reference material is needed, much valuable time is lost in searching for it, or the existence of certain material already in the files is forgotten or overlooked and considerable trouble and expense is incurred in duplicating it. One often remembers having seen certain data, but cannot recall the title or author of the paper, nor the journal or book in which they are hidden away.

We regard with interest the man who has arranged his reference material so conveniently and systematically that he can promptly say whether or not he has certain information, and if he has, produce it. He saves much time by not having to search for things. There is real satisfaction, too, in knowing that a certain folder contains all the information that we have on some particular subject: that in our consideration of the topic to which it relates, nothing is being overlooked. If we are called from the office to the field, we turn to our files and select those folders pertaining to the work that we are to do, and everything that we have applicable to the work in hand will be in these folders. Furthermore, we are able to send to our office from a distance, and an assistant selects from the files exactly what is wanted. The finding of something particularly wanted should not be dependent upon the memory of one clerk. Office personnel changes, and the filing system must be independent of personalities and labor turnover. All this is possible if one gives thought to the matter of developing a suitable system of classification and applies it intelligently to the material to be classified.

Much clerical work may be involved in making the original classification and arranging the material in proper sequence, particularly if the volume of accumulated material is large. Once the primary classification and arrangement is accomplished, however, subsequent filing of additional data in accordance with the same plan adds but little to the daily routine. The greater difficulty comes in planning the classification so that it will be sufficiently elastic and comprehensive to provide for future expansion or specialization in different directions.

Of the various plans that have been developed for filing, indexing, and arranging technical data, none has proved more satisfactory than the decimal system of classification in conjunction with a comprehensive card index arranged according to subject matter. The decimal system is one originally devised by M. Dewey and elaborated by him in his book, "A Decimal Classification and Relative Index for Libraries, Clippings, Notes, etc." In the Dewey decimal system, the entire field of knowledge is divided into ten main divisions, numbered by the digits from 0 to 9, thus:

0.—General Works.
1.—Philosophy.
2.—Religion.
3.—Sociology.
4.—Philology.
5.—Natural Sciences.
6.—Useful Arts.
7.—Fine Arts.
8.—Literature.
9.—History.

These major divisions are subdivided by the addition of other digits; for example:

610.—Medicine.
620.—Engineering.
630.—Agriculture.
640.—Domestic Economy.
650.—Communication and Commerce.
660.—Chemical Technology.
670.—Manufactures.
680.—Mechanical Trades.
690.—Building.

Further subdivision within the field of engineering gives the following:

620.—Engineering.
621.—Mechanical Engineering.
622.—Mining Engineering.
623.—Military Engineering.
624.—Bridge and Structural Engineering.

625.—Railroad and Highway Engineering.
626.—Canal Engineering (Irrigation Engineering).
627.—River and Harbor Engineering.
628.—Sanitary Engineering and Water Works.
629.—Other Branches of Engineering.

From the standpoint of one interested in some specialized industry, such as the petroleum industry, it is found that the system developed by Dewey is too broad. Being all-inclusive, it subordinates the particular things in which we are interested to the main divisions of knowledge in such a way that much of the material that we should like to have together is widely scattered. The decimal classification given in the following pages is modeled after the plan used by Dewey, except that all knowledge is considered to be subordinated to the field of petroleum technology, to which the whole classification applies. It is intended to provide an orderly and systematic arrangement of reference material for individuals whose chief interest lies in the field of petroleum technology.

The main framework of the classification is indicated in the abridged list of topics or subdivisions of the field of petroleum technology printed herewith. In the complete index, which will be printed in succeeding issues of *The Petroleum Engineer*, each of the divisions in this list is divided into ten subdivisions, thus providing 1000 topics to each of which a whole number between 0 and 1000 is assigned. Each of these numbers is followed by a decimal point, and to the right of the decimal point additional digits may be provided if our needs require such detailed classification. The decimal point is used merely for convenience in reading and has no special significance.

An effort has been made to include in the classification a number for every topic of any importance pertaining to the petroleum and related industries. Where topics have been overlooked, it should be easy to extend the classification, where necessary, by providing a number that would place the topic in its proper sequence with respect to other related topics.

Once familiar with the system followed, one should be able to assemble readily a suitable number for classification. For example, if we wished to file a paper descriptive of a new type of oil well plunger pump, it would at once be recognized that the paper pertained to oil production methods, and therefore should be assigned a number between 500 and 600. Further reference to the subdivisions of the classification between 500 and 600 would show that the paper is related to 510, covering extraction of oil from wells; and inspection of the numbers between 510 and 520 enables us to place it even more definitely under the number 514. For some individuals, the number 510 would be sufficiently detailed, but if one were a petroleum production engineer to whom the topics listed under 510 are important, it might be desirable to classify even more minutely, and if such were the case, the full number 514.1 would be assigned. One of the chief advantages of the decimal system is that it may be expanded indefinitely to meet the needs of the most specialized fields.

In starting a series of files it is preferable to avoid the more detailed subdivisions until accumulation of material necessitates further subdivision. When a particular folder becomes unwieldy or contains too much material to permit easy selection of the reference sought, its contents may be reclassified among nine new folders, leaving the original folder for future filing of general data. The nine new ones will thenceforth be used for receiving the bulk of the new material, which will be marked with one additional digit added to indicate its proper file number under the enlarged system. The files thus grow and ramify in accordance with the owner's interests and may be indefinitely expanded as these interests lead one to file data pertaining to the more specialized fields.

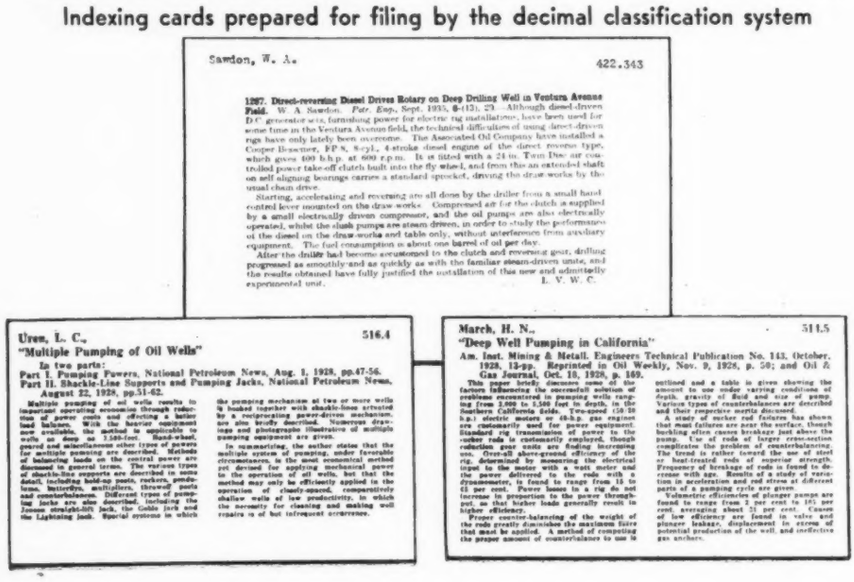
Most individuals interested in the oil industry will also be concerned to some extent with the related fields, such as the natural gas industry, the oil shale industry, the natural asphalt industry, and the mineral wax industry. Sharp lines separating these different divisions of the general field of petroleum technology are difficult to draw and the various phases of the industry promise to become even more closely related in future. An effort has therefore been made to include these related industries in the general plan of the classification, so that information pertaining to either may find a place without the necessity of duplicating files or numbers.

Applications of the Classification

The classification will be of use either in arranging clippings, pamphlets, drawings, photographs, catalogs, technical papers, etc., in filing cabinets, or in arranging a card-catalog subject file for convenience in reference and in bibliographic work. Most technologists will find it advisable to keep both, in which case they should be properly coördinated; that is, the system of numbering cards in the card catalog should be used for numbering the folders in the filing cabinet. The card catalog thus becomes a convenient index or guide to material in the larger and perhaps less accessible filing cabinet.

Filing of Clippings, Pamphlets, Technical Papers, etc., in Filing Cabinets. For this purpose, any standard make of filing cabinet may be adopted, but the type having drawers of sufficient size to receive 9½-in. by 11¾-in. folders, filed vertically, i.e., on edge, is preferred. The folders are numbered in sequence to conform with the classification and the numbers may be placed on projecting tabs on the edges of the folders, so that they are readily visible when the filing cabinet drawers are open. The subject to which each folder is assigned may also be lettered or typed across the top edge of the folder, this edge being left slightly projecting from the main body of material in the file. Major subdivisions in the files are conveniently separated by substantial indexing cards, on the projecting tabs of which the classification numbers are

Indexing cards prepared for filing by the decimal classification system


Sawdon, W. A. 422.343

1297. Direct-reversing Diesel Drives Rotary on Deep Drilling Well in Ventura Avenue Field. W. A. Sawdon. *Pet. Eng.*, Sept. 1935, 6-(12), 29.—Although diesel-driven D-C generator sets, furnishing power for electric rig installations, have been used for some time in the Ventura Avenue field, the technical difficulties of using direct-driven rigs have only lately been overcome. The Associated Oil Company have installed a Cooper Bessemer, FP S, 8-cyl., 4-stroke diesel engine of the direct reverse type, which gives 600 b.h.p. at 600 r.p.m. It is fitted with a 24-in. Twin Disc air controlled power take-off clutch built into the fly wheel, and from this an extended shaft on self aligning bearings carries a standard sprocket, driving the draw-works by the usual chain drive.

Starting, accelerating and reversing are all done by the driller from a small hand control lever mounted on the draw works. Compressed air for the clutch is supplied by a small electrically driven compressor, and the oil pumps are also electrically operated, whilst the clank pumps are steam driven, in order to study the performances of the diesel on the draw-works and table only, without interference from auxiliary equipment. The fuel consumption is about one barrel of oil per day.

After the driller had become accustomed to the clutch and reversing gear, drilling progressed as smoothly and as quickly as with the familiar steam-driven units, and the results obtained have fully justified the installation of this new and admittedly experimental unit.

L. V. W. C.

Uren, L. C. 516.4
"Multiple Pumping of Oil Wells"
In two parts:
Part I. Pumping Powers. National Petroleum News, Aug. 1, 1928, pp.47-56.
Part II. Shackle-Line Supports and Pumping Jacks. National Petroleum News, August 22, 1928, pp.51-62.

Multiple pumping of oil wells results in important operating economies through reduction of power costs and effecting a better load balance. With the heavier equipment now available, the method is applicable to wells as deep as 7,500-feet. Band-wheel, geared and miscellaneous other types of powers for multiple pumping are described. Methods of balancing loads on the central power are discussed in general terms. The various types of shackle-line supports are described in some detail, including hold-up posts, rockers, pendulums, butterflys, anti-fallers, thrownoff parts and counterbalances. Different types of pumping jacks are also described, including the Jensen straight-lift jack, the Cobb jack and the Lightning jack. Special systems in which the pumping mechanism of two or more wells is hooked together with shackle-lines actuated by a reciprocating power-driven mechanism, are also briefly described. Numerous drawings and photographs illustrative of multiple pumping equipment are given.

In commenting, the author states that the multiple system of pumping, under favorable circumstances, is the most economical method yet devised for applying mechanical power to the operation of oil wells, but that the method may only be efficiently applied to the operation of closely-spaced, comparatively shallow wells of low productivity, in which the necessity for cleaning and making well repairs is of but infrequent occurrence.

March, H. N. 511.5
"Deep Well Pumping in California"
Am. Inst. Mining & Metall. Engineers Technical Publication No. 143. October, 1928, 13-pp. Reprinted in Oil Weekly, Nov. 9, 1928, p. 58; and Oil & Gas Journal, Oct. 18, 1928, p. 169.

This paper briefly discusses some of the factors influencing the successful solution of problems encountered in pumping wells ranging from 7,000 to 7,500 feet in depth, in the Southern California fields. Two-speed 150-750 h.p.) electric motors or 1000-h.p. engines are customarily used for power equipment. Standard rig transmission of power to the walking-beam is customarily employed, though reduction gear units are finding increasing use. Over-all above-ground efficiency of the rig, determined by measuring the electrical input to the motor with a watt meter and the power delivered to the rods with a dynamometer, is found to range from 15 to 25 per cent. Power losses in a rig do not increase in proportion to the power throughput, so that heavier loads generally result in higher efficiency.

Proper counter-balancing of the weight of the rods greatly diminishes the maximum force that must be applied. A method of computing the proper amount of counterbalance to use is outlined and a table is given showing the amount to use under varying conditions of depth, gravity of fluid and size of pump. Various types of counterbalances are described and their respective merits discussed.

A study of sucker rod failures has shown that most failures are near the surface, though buckling often causes breakage just above the pump. Use of rods of larger cross-section complicates the problem of counterbalancing. The trend is rather toward the use of steel of heat-treated rods of superior strength. Frequency of breakage of rods is found to decrease with age. Results of a study of variation in acceleration and rod stress at different parts of a pumping cycle are given.

Volumetric efficiencies of plunger pumps are found to range from 72 per cent to 101 per cent, averaging about 91 per cent. Causes of low efficiency are found in valve and plunger leakage, displacement in excess of potential production of the well, and ineffective gas anchors.

printed, lettered, or stamped. These cards serve to lead one rapidly to the particular folder sought. All material in such a file should be clipped or folded to the standard size for which the folders and cabinets are designed (usually 8½ in. by 11 in. or 8½ in. by 14 in.). It will be found that full-page clippings from most of the technical journals can be trimmed to 8½ in. by 11 in. without sacrificing anything more than margins.

Photographs and Half-Tone Clippings may conveniently be filed by mounting them on loose-leaf pages, numbered to conform with the decimal classification and arranged in numerical sequence in a loose-leaf album. An alternative plan is that of mounting them on stiff cards and filing on edge in a card-catalog filing cabinet, but this plan requires more careful mounting of the material, and the material filed in this way is more bulky.

The Card Catalog Method of Recording Bibliographic References is too well known to require detailed description. Such a card file will be found useful, not only in maintaining a bibliography of references on subjects in which one is interested, but also in preserving in abbreviated form an index of material in the filing cabinets. If the practice is followed of preserving technical journals and professional society transactions in chronologically arranged volumes, so that individual papers cannot be filed separately, a subject catalog in card index form will be invaluable as a guide to the bound material. If one does not own copies of the books, technical papers, and other material to which the bibliographic references in the card catalog relate, but has access to them through membership in a technical library, brief abstracts may be added to the cards, giving the salient features and principal conclusions in each paper. Such abstracts will be found useful in recalling the content of the paper or book at some future time, and may conveniently be placed on the lower half of the card, or on the back.

If the card file is to be merely a collection of bibliographic references, the cards are preferably of library card-catalog size (3 in. by 5 in.). Usually only the title, author's name, date, and the name of the publication in which the material is printed will be given, though there is room on such a card for a very brief outline or summary of the subject matter. If a more detailed abstract of each reference is to be preserved, a card of larger size should be used—either 4 in. by 6 in. or 5 in. by 8 in. being suitable. The classification number is conveniently placed in the upper right-hand corner of the card, and the author's name in the upper left. Cards having the same classification number are arranged in the files in order of the initial letters of the author's last name.

The writer has found the abstracts printed in the Journal of the Institute of Petroleum (formerly Institution of Petroleum Technologists) especially helpful in maintaining a card file. These may be purchased printed on only one side of the paper, and may then be clipped and mounted on cards. Abstracts printed in connection with papers published by the various professional societies and by some of the technical journals serving the petroleum industry are also well adapted for use in card files. There is still need for some journal or agency to publish regularly a series of carefully prepared, brief abstracts of the best technical papers currently appearing in the technical press, which could be made available at small cost to technologists interested in maintaining a card file.

Further Suggestions on Use of the Decimal Classification. Until one becomes familiar with the classification, it may be found more convenient in assigning numbers, to work from the alphabetical index, which will be printed in the pages of *The Petroleum Engineer* after publication of the subject index is complete. After a file has been in use for some time, however, the user will know approximately where a particular subject should be filed, and inspection of that part of the subject classification will give the proper number to be assigned.

It may be possible to file a particular reference under different numbers, depending upon the significance attached to its title and breadth of scope. One must fully consider the utility of the materials and decide under which of the possible numbers it will serve its most useful purpose. A system of cross-references under other related numbers will be useful in leading one to the particular material sought.

GENERAL OUTLINE OF THE CLASSIFICATION

000 to 100. General Data Pertaining to Petroleum and Related Industries

000. General reference, text, and hand books on petroleum technology and the petroleum industry.
010. Periodicals and technical journals.
020. Publications of technical societies, organizations, and institutions.
030. Publications of government agencies, bureaus, and departments.
040. Bibliographies.

Filing cabinet for 9½-in. by 11¾-in. folders (at left) and for 4-in. by 5-in. cards (at right)

050. Nomenclature: glossaries, dictionaries, and cyclopedia.
060. Tables and formulae.
070. Patents and patent office publications.
080. Petroleum technologists, engineers, and companies: directories and biographies, addresses, etc.
090. Miscellaneous general data on petroleum technology and the petroleum industry. General unclassified data.

100 to 200. Geographical Distribution of Petroleum: Oil Fields, Properties, and Districts; Descriptions and Maps

100. Geographies, general and economic, and other books descriptive of the geographic distribution of petroleum.
110. North American oil fields, districts, and properties.
120. South American oil fields, districts, and properties.
130. European oil fields, districts, and properties.
140. Asiatic oil fields, districts, and properties.
150. African oil fields, districts, and properties.
160. Oceania and Malaysian oil fields, districts, and properties.
190. Other islands not included in foregoing continental and insular classification.

200 to 300. Physical and Chemical Properties of Petroleum: Examination, Testing, and Sampling

200. General reference, text, and hand books and general articles on physical and chemical properties, analyses, testing, and sampling.

210. Physical properties of petroleum, natural gas, and other bitumens and methods of determination: General data on physical properties.
220. Chemical properties of petroleum, natural gas, and other bitumens, and methods of determination: General data on chemical properties.
230. Thermal properties of petroleum, natural gas, and other bitumens, and methods of determination: General data on thermal properties.
240. Medicinal and physiological properties.
250. Power and thermal efficiency tests.
260. Tests of various species and fractions of petroleum and bitumen.
270. Specifications for purchase of various species and fractions of petroleum and other bitumens.
280. Sampling liquid, gaseous, and solid hydrocarbons.
290. Miscellaneous other data on properties of bitumens; examination, testing, and sampling.

300 to 400. Exploration and Prospecting for Petroleum and Other Bitumens

300. General geological reference, text, and hand books.
310. Origin and genesis of petroleum; geochemistry.
320. Stratigraphic distribution of petroleum: palaeontological applications.
330. Economic geology of petroleum. Types of deposits. Structural features and factors influencing migration and accumulation.
340. Lithology and petrology of bituminous rocks and associated rocks.
350. Indications of petroleum and other bitumens: associations of petroleum and natural gas in nature: surface and sub-surface signs.
360. Geologic surveys: practical field methods of study and collecting data.
370. Selecting test well sites.
380. Acquisition of lands, leases, and permits; legal restrictions.
390. Miscellaneous other data on exploration, prospecting, and geology of petroleum.

400 to 500. Development of Deposits of Oil, Gas, and Other Bitumens

400. General reference, text, and hand books on development.
410. Choice of well sites; well spacing; development programs.
420. Drilling methods.
430. Casing wells: casing, casing methods, and casing appliances.
440. Exclusion of water and gas from wells: control of high-pressure gas and hydrostatic pressures. Oil field hydrology.
450. Finishing the well; preparation for production.
460. Development of deposits of solid hydrocarbons.
470. Mine development, principles and methods.
480. Mine equipment.
490. Other processes, methods, equipment, etc., pertaining to development of hydrocarbons.

500 to 600. Production or Extraction of Petroleum, Natural Gas, Oil Shale, and Other Related Hydrocarbons

500. General reference, text, and hand books on production methods.
510. Extraction of oil from wells.
520. Extraction of gas from wells.
530. Management and care of oil and gas wells; methods of stimulating production and increasing efficiency.
540. Gathering and preliminary treatment of gas and oil.
550. Mining or extraction of hydrocarbon substances through mine openings.
560. Surface mining methods.
570. Underground mining methods.
580. Handling and treatment of solid hydrocarbons, oil shales, and sands.
590. Miscellaneous auxiliary plants and departments necessary in oil producing and related industries.

600 to 700. Transportation, Storage, and Gauging of Petroleum, Natural Gas, Shale Oil, Natural Asphalt, and Related Bitumens

600. General reference, text, and hand books on transportation, storage, and gauging.
610. Transportation of oil.
620. Natural gas transmission and compression.
630. Transportation of solid bitumens.
640. Oil storage.
650. Gas storage.
660. Storage of solid hydrocarbons.
670. Gauging and metering oil.
680. Gauging and metering gas: measurement of volume and pressure.
690. Methods of estimating weights and volumes of bituminous sands, natural asphalts, and other solid hydrocarbons.

700 to 800. Oil Refineries and Refinery Practice

700. General reference, text, and hand books on refinery practice.
710. Types of refineries.
720. Refinery processes: theoretical considerations.
730. Refinery construction, equipment, and materials.
740. Refinery operation and control.
750. Specific products and their manufacture. Refined products obtained from petroleum.
760. Miscellaneous auxiliary plants and departments about the refinery.
770. Condensation of vapors from hydrocarbon gases.
780. Manufacture of carbon black from natural gas.
790. Other data on refining of petroleum and related products.

800 to 900. Utilization of Petroleum and Its Products

800. General reference, text, and hand books on petroleum utilization.
810. Utilization of petroleum and related products in developing heat and power.
820. Utilization of petroleum products in developing light.
830. Utilization of petroleum products for lubrication and similar purposes.
840. Structural uses of petroleum and petroleum products.
850. Use of petroleum products in hydrocarbon gas manufacture.
860. Medicinal and pharmaceutical uses.
870. Metallurgical and chemical uses.
880. Use of petroleum and petroleum products in soap manufacture, as cleansing agents, and solvents.
890. Miscellaneous other uses for petroleum, petroleum products, and related hydrocarbons.

900 to 1000. Economics of the Petroleum and Related Industries

900. General reference, text, and hand books on petroleum economics.
910. Statistics of the petroleum industry and regional economics.
920. Oil company finance, organization, and control.
930. Management of oil companies and related organizations.
940. Cost-accounting for the petroleum and related industries: office methods and records.
950. Valuation of plant and property for the petroleum and related industries.
960. Marketing of petroleum and its products: economic influence of market conditions on the petroleum industry.
970. Conservation of petroleum resources.
980. Legislation and government regulation of the petroleum and related industries.
990. Other data on economic phases of the petroleum and related industries.

ENERGY REQUIRED TO LIFT FLUID, THOUSAND FT.-LB. PER 42-GAL. BBL.

Height of lift, ft.	Sp. gr. of fluid heavier than water				Fresh water (sp. gr. = 1) (A.P.I. gr = 10)	Gravity of fluid lighter than water, deg. A.P.I.									
	1.16	1.12	1.08	1.04		12	16	20	24	28	32	36	40	44	48
10,100	4096.8	3955.6	3814.3	3673.0	3531.8	3487.6	3342.9	3303.1	3218.2	3137.4	3060.6	2987.9	2918.5	2851.5	2787.8
10,200	4137.3	3994.7	3852.0	3709.3	3566.7	3522.2	3426.5	3335.8	3250.0	3168.4	3090.9	3017.5	2947.4	2879.8	2815.4
10,300	4177.9	4033.9	3889.8	3745.7	3601.7	3556.7	3460.1	3368.5	3281.9	3199.5	3121.2	3047.0	2976.3	2908.0	2843.0
10,400	4218.4	4073.1	3927.6	3782.1	3636.7	3591.2	3493.7	3401.2	3313.8	3230.6	3151.5	3076.6	3005.2	2936.2	2870.6
10,500	4259.0	4112.2	3965.3	3818.4	3671.6	3625.8	3527.3	3433.9	3345.6	3261.6	3181.8	3106.2	3034.1	2964.5	2898.2
10,600	4299.6	4151.4	4003.1	3854.8	3706.6	3660.3	3560.9	3466.6	3377.5	3292.7	3212.1	3135.8	3063.0	2992.7	2925.8
10,700	4340.1	4190.5	4040.9	3891.2	3741.6	3694.8	3594.5	3499.3	3409.3	3323.7	3242.4	3165.4	3091.9	3020.9	2953.4
10,800	4380.7	4229.7	4078.6	3927.5	3776.5	3729.3	3628.0	3532.0	3441.2	3354.8	3272.7	3195.0	3120.8	3049.2	2981.0
10,900	4421.3	4268.9	4116.4	3963.9	3811.5	3763.9	3661.6	3564.7	3473.1	3385.9	3303.0	3224.5	3149.7	3077.4	3008.6
11,000	4461.8	4308.0	4154.2	4000.3	3846.5	3798.4	3695.2	3597.4	3504.9	3416.9	3333.3	3254.1	3178.6	3105.6	3036.2
11,100	4502.4	4347.2	4191.9	4036.6	3881.4	3832.9	3728.8	3630.1	3536.8	3448.0	3363.6	3283.7	3207.5	3133.9	3063.8
11,200	4542.9	4386.4	4229.7	4073.0	3916.4	3867.5	3762.4	3662.8	3568.7	3479.1	3393.9	3313.3	3236.4	3162.1	3091.4
11,300	4583.5	4425.5	4267.4	4109.4	3951.4	3902.0	3796.0	3695.6	3600.5	3510.1	3424.2	3342.9	3265.2	3190.3	3119.0
11,400	4624.1	4464.7	4305.2	4145.7	3986.4	3936.5	3829.6	3728.3	3632.4	3541.2	3454.5	3372.5	3294.1	3218.6	3146.6
11,500	4664.6	4503.9	4343.0	4182.1	4021.3	3971.1	3863.2	3761.0	3664.2	3572.2	3484.8	3402.0	3323.0	3246.8	3174.2
11,600	4705.2	4543.0	4380.7	4218.5	4056.3	4005.6	3896.8	3793.7	3696.1	3603.3	3515.1	3431.6	3351.9	3275.0	3201.8
11,700	4745.8	4582.2	4418.5	4254.8	4091.3	4040.1	3930.4	3826.4	3728.0	3634.4	3545.5	3461.2	3380.8	3303.3	3229.4
11,800	4786.3	4621.4	4456.3	4291.2	4126.2	4074.7	3964.0	3859.1	3759.8	3665.4	3575.8	3490.8	3409.7	3331.5	3257.0
11,900	4826.9	4660.5	4494.0	4327.6	4161.2	4109.2	3997.6	3891.8	3791.7	3696.5	3606.1	3520.4	3438.6	3359.7	3284.6
12,000	4867.4	4699.7	4531.8	4363.9	4196.2	4143.7	4031.2	3924.5	3823.6	3727.6	3636.4	3550.0	3467.5	3388.0	3312.2
12,100	4908.0	4738.8	4569.6	4400.3	4231.1	4178.3	4064.8	3957.2	3855.4	3758.6	3666.7	3579.5	3496.4	3416.2	3339.8
12,200	4948.6	4778.0	4607.3	4436.7	4266.1	4212.8	4098.3	3989.9	3887.3	3789.7	3697.0	3609.1	3525.3	3444.4	3367.4
12,300	4989.1	4817.2	4645.1	4473.0	4301.1	4247.3	4131.9	4022.6	3919.1	3820.7	3727.3	3638.7	3554.2	3472.7	3395.0
12,400	5029.7	4856.3	4682.9	4509.4	4336.0	4281.8	4165.5	4055.3	3951.0	3851.8	3757.6	3668.3	3583.1	3500.9	3422.6
12,500	5070.2	4895.5	4720.6	4545.8	4371.0	4316.4	4199.1	4088.0	3982.9	3882.9	3787.9	3697.9	3612.0	3529.1	3450.2
12,600	5110.8	4934.7	4758.4	4582.1	4406.0	4350.9	4232.7	4120.7	4014.7	3913.9	3818.2	3727.5	3640.9	3557.4	3477.9
12,700	5151.4	4973.8	4796.2	4618.5	4440.9	4385.4	4266.3	4153.4	4046.6	3945.0	3848.5	3757.0	3669.8	3585.6	3505.5
12,800	5191.9	5013.0	4833.9	4654.8	4475.9	4420.0	4299.9	4186.1	4078.5	3976.1	3878.8	3786.6	3698.7	3613.8	3533.1
12,900	5232.5	5052.2	4871.7	4691.2	4510.9	4454.5	4333.5	4218.8	4110.3	4007.1	3909.1	3816.2	3727.6	3642.1	3560.7
13,000	5273.1	5091.3	4909.5	4727.6	4545.8	4489.0	4367.1	4251.5	4142.2	4038.2	3939.4	3845.8	3756.5	3670.3	3588.3
13,100	5313.6	5130.5	4947.2	4763.9	4580.8	4523.6	4400.7	4284.2	4174.1	4069.3	3969.7	3875.4	3785.4	3698.5	3615.9
13,200	5354.2	5169.6	4985.0	4800.3	4615.8	4558.1	4434.3	4316.9	4205.9	4100.3	4000.0	3905.0	3814.3	3726.8	3643.5
13,300	5394.7	5208.8	5022.7	4836.7	4650.7	4592.6	4467.9	4349.6	4237.8	4131.4	4030.3	3934.5	3843.2	3755.0	3671.1
13,400	5435.3	5248.0	5060.5	4873.0	4685.7	4627.2	4501.5	4382.3	4269.6	4162.4	4060.6	3964.1	3872.1	3783.2	3698.7
13,500	5475.9	5287.1	5098.3	4909.4	4720.7	4661.7	4535.1	4415.0	4301.5	4193.5	4090.9	3993.7	3901.0	3811.5	3726.3
13,600	5516.4	5326.3	5136.0	4945.8	4755.6	4696.2	4568.6	4447.7	4333.4	4224.6	4121.2	4023.3	3929.9	3839.7	3753.9
13,700	5557.0	5365.5	5173.8	4982.1	4790.6	4730.7	4602.2	4480.4	4365.2	4255.6	4151.6	4052.9	3958.8	3867.9	3781.5
13,800	5597.6	5404.6	5211.6	5018.5	4825.6	4765.3	4635.8	4513.2	4397.1	4286.7	4181.8	4082.5	3987.6	3896.2	3809.1
13,900	5638.1	5443.8	5249.3	5054.9	4860.6	4799.8	4669.4	4545.9	4429.0	4317.8	4212.1	4112.0	4016.5	3924.4	3836.7
14,000	5678.7	5483.0	5287.1	5091.2	4895.5	4834.3	4703.0	4578.6	4460.8	4348.8	4242.4	4141.6	4045.4	3952.6	3864.3
14,100	5719.2	5522.1	5324.9	5127.6	4930.5	4868.9	4736.6	4611.3	4492.7	4379.9	4272.7	4171.2	4074.3	3980.9	3891.9
14,200	5759.8	5561.3	5362.6	5164.0	4965.5	4903.4	4770.2	4644.0	4524.5	4410.9	4303.0	4200.8	4103.2	4009.1	3919.5
14,300	5800.4	5600.5	5400.4	5200.3	5000.4	4937.9	4803.8	4676.7	4556.4	4442.0	4333.3	4230.4	4132.1	4037.3	3 47.1
14,400	5840.9	5639.6	5438.2	5236.7	5035.4	4972.5	4837.4	4709.4	4588.3	4473.1	4363.6	4260.0	4161.0	4065.6	3974.7
14,500	5881.5	5678.8	5475.9	5273.1	5070.4	5007.0	4871.0	4742.1	4620.1	4504.1	4393.9	4289.5	4189.9	4093.8	4002.3
14,600	5922.1	5717.9	5513.7	5309.4	5105.3	5041.5	4904.6	4774.8	4652.0	4535.2	4424.2	4319.1	4218.8	4122.0	4029.9
14,700	5962.6	5757.1	5551.5	5345.8	5140.3	5076.1	4938.2	4807.5	4683.9	4566.3	4454.5	4348.7	4247.7	4150.3	4057.5
14,800	6003.2	5796.3	5589.2	5382.2	5175.3	5110.6	4971.8	4840.2	4715.7	4597.3	4484.8	4378.3	4276.6	4178.5	4085.1
14,900	6043.7	5835.4	5627.0	5418.5	5210.2	5145.1	5005.4	4872.9	4747.6	4628.4	4515.1	4407.9	4305.5	4206.7	4112.7
15,000	6084.3	5874.6	5664.8	5454.9	5245.2	5179.7	5039.0	4905.6	4779.5	4659.4	4545.4	4437.4	4334.4	4235.0	4140.3

In Bethlehem Sucker Rods

elastic properties, ductility and impact values

are correctly balanced to meet the service requirements

BETHLEHEM STEEL

BETHLEHEM's intimate knowledge of oil-field conditions and the experience of 50 years of alloy steel manufacture combine to produce sucker rods that will do the work most economically. In particular, the elastic properties, ductility and impact values are carefully considered and balanced to meet service requirements.

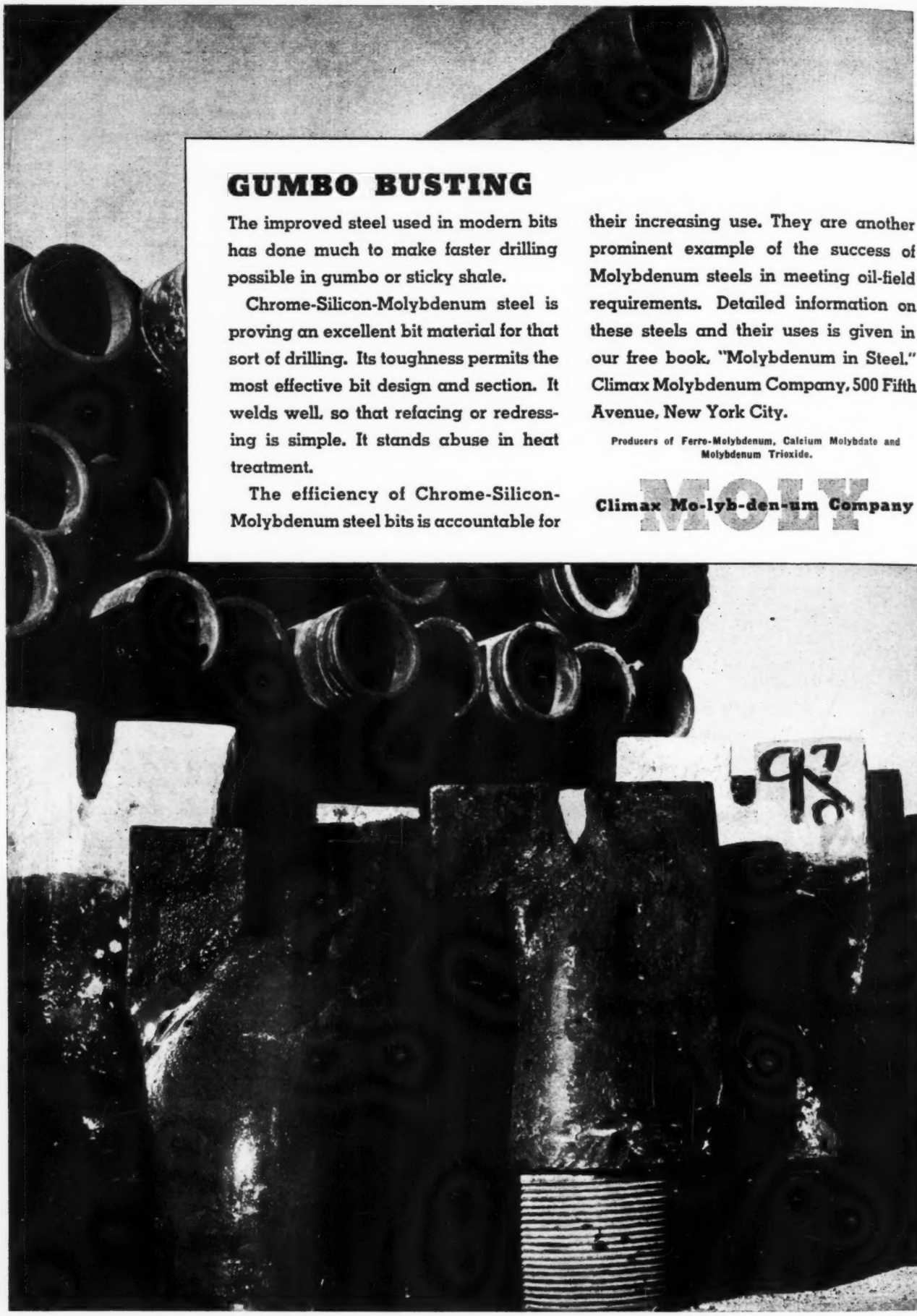
The outstanding performance of Bethlehem Sucker Rods is evidence of the fine balance of requisite qualities built into them. They are being used in some of the country's toughest oil fields—by large operators and independents alike. They are effecting economies in every major oil field.

BETHLEHEM STEEL COMPANY

MINIMUM[1] CLEARANCE BETWEEN TOOL JOINTS AND WALL OF WELL, IN.

Size of bit, in.	Outside diam. of tool joint, in.												
	3⅛	3¾	4¼	4½	4⅝	5½	5¾	6¾	7	7¾	8	8⅞	10
3⅞	.375	.0625											
4¼	.5625	.250											
4¾	.8125	.500	.250	.125	.0625								
5⅝	1.250	.9375	.6875	.5625	.500	.0625							
6	1.4375	1.125	.875	.750	.6875	.250	.125						
6⅛	1.500	1.1875	.9375	.8125	.750	.3125	.1875						
6½	1.6875	1.375	1.125	1.000	.9375	.500	.375						
6¾	1.8125	1.500	1.250	1.125	1.0625	.625	.500						
7	1.9375	1.625	1.375	1.250	1.1875	.750	.625	.125					
7½	2.1875	1.875	1.625	1.500	1.4375	1.000	.875	.375	.250				
7⅝	2.250	1.9375	1.6875	1.5625	1.500	1.0625	.9375	.4375	.3125				
7⅞	2.375	2.0625	1.8125	1.6875	1.625	1.1875	1.0625	.5625	.4375	.0625			
8⅜	2.625	2.3125	2.0625	1.9375	1.875	1.4375	1.3125	.8125	.6875	.3125	.1875		
8⅝	2.750	2.4375	2.1875	2.0625	2.000	1.5625	1.4375	.9375	.8125	.4375	.3125		
9⅝	3.250	2.9375	2.6875	2.5625	2.500	2.0625	1.9375	1.4375	1.3125	.9375	.8125	.375	
9⅞	3.375	3.0625	2.8125	2.6875	2.625	2.1875	2.0625	1.5625	1.4375	1.0625	.9375	.500	
10⅝	3.750	3.4375	3.1875	3.0625	3.000	2.5625	2.4375	1.9375	1.8125	1.4375	1.3125	.875	.3125
11	3.9375	3.625	3.375	3.250	3.1875	2.750	2.625	2.125	2.000	1.625	1.500	1.0625	.500
12¼	4.5625	4.250	4.000	3.875	3.8125	3.375	3.250	2.750	2.625	2.250	2.125	1.6875	1.125
13¾	5.3125	5.000	4.750	4.625	4.5625	4.125	4.000	3.500	3.375	3.000	2.875	2.4375	1.875
14¾	5.8125	5.500	5.250	5.125	5.0625	4.625	4.500	4.000	3.875	3.500	3.375	2.9375	2.375
15½	6.1875	5.875	5.625	5.500	5.4375	5.000	4.875	4.375	4.250	3.875	3.750	3.3125	2.750
17	6.9375	6.625	6.375	6.250	6.1875	5.750	5.625	5.125	5.000	4.625	4.500	4.0625	3.500
17½	7.1875	6.875	6.625	6.500	6.4375	6.000	5.875	5.375	5.250	4.875	4.750	4.3125	3.750
18⅝	7.750	7.4375	7.1875	7.0625	7.000	6.5625	6.4375	5.9375	5.8125	5.4375	5.3125	4.875	4.3125
20¾	8.8125	8.500	8.250	8.125	8.0625	7.625	7.500	7.000	6.875	6.500	6.375	5.9375	5.375
25½	11.1875	10.875	10.625	10.500	10.4375	10.000	9.875	9.375	9.250	8.875	8.750	8.3125	7.750
27	11.9375	11.625	11.375	11.250	11.1875	10.750	10.625	10.125	10.000	9.625	9.500	9.0625	8.500

[1]Inasmuch as the bit may drill a hole of greater diameter than its own.



GUMBO BUSTING

The improved steel used in modern bits has done much to make faster drilling possible in gumbo or sticky shale.

Chrome-Silicon-Molybdenum steel is proving an excellent bit material for that sort of drilling. Its toughness permits the most effective bit design and section. It welds well, so that refacing or redressing is simple. It stands abuse in heat treatment.

The efficiency of Chrome-Silicon-Molybdenum steel bits is accountable for their increasing use. They are another prominent example of the success of Molybdenum steels in meeting oil-field requirements. Detailed information on these steels and their uses is given in our free book, "Molybdenum in Steel." Climax Molybdenum Company, 500 Fifth Avenue, New York City.

Producers of Ferro-Molybdenum, Calcium Molybdate and Molybdenum Trioxide.

Climax Mo-lyb-den-um Company

MOLY

DIAMETER—LENGTH MULTIPLIERS* $\left(\sqrt{\frac{d^{5\frac{1}{3}}}{L}}\right)$ OF WEYMOUTH'S FORMULA

Length of line, miles	Actual internal diameter of pipe, in.											
	2.067	3.068	4.026	6.065	7.981	10.02	12.00	13.25	15.25	17.25	19.25	21.25
1	6.93	19.87	41.02	122.3	254.3	466.5	754.5	982.6	1429.5	1974.3	2660.3	3462.6
5	3.10	8.89	18.34	54.73	113.7	208.6	337.4	439.5	639.0	888.4	1190.0	1548.5
10	2.19	6.28	12.96	38.67	80.42	147.5	238.6	310.7	452.1	627.9	841.3	1095.0
15	1.79	5.13	10.59	31.60	65.66	120.4	194.8	253.7	369.1	512.7	686.9	894.0
20	1.55	4.44	9.17	27.37	56.86	104.2	168.7	219.7	319.6	444.0	594.9	774.3
25	1.39	3.97	8.20	24.48	50.86	93.29	150.9	196.5	285.9	397.1	532.1	692.5
30	1.26	3.63	7.49	22.34	46.43	85.16	137.7	179.4	261.0	362.5	485.7	632.2
35	1.17	3.36	6.93	20.73	42.98	78.85	127.5	166.1	241.6	335.6	449.7	585.3
40	1.10	3.14	6.49	19.35	40.21	73.75	119.3	155.4	226.0	314.0	420.6	547.5
45	1.02	2.96	6.12	18.24	37.91	69.54	112.5	146.5	213.1	296.0	396.6	516.2
50	0.98	2.81	5.80	17.31	35.96	65.97	106.7	139.0	202.2	280.8	376.2	489.7
55	0.92	2.68	5.53	16.50	34.29	62.90	101.7	132.5	192.8	267.7	358.7	466.9
60	0.89	2.57	5.29	15.80	32.83	60.22	97.40	126.9	184.6	256.3	343.4	447.0
65	0.85	2.47	5.09	15.18	31.54	57.86	93.58	121.9	177.3	246.3	330.0	429.5
70	0.83	2.37	4.90	14.63	30.39	55.75	90.18	117.4	170.9	237.3	318.0	413.9
75	0.80	2.30	4.73	14.14	29.36	53.86	87.12	113.5	165.1	229.3	307.2	399.8
80	0.77	2.22	4.58	13.68	28.43	52.15	84.35	109.9	159.8	222.0	297.4	387.1
85	0.75	2.16	4.45	13.27	27.59	50.60	81.83	106.6	155.1	215.4	288.6	375.6
90	0.73	2.10	4.32	12.89	26.81	49.17	79.53	103.6	150.7	209.3	280.4	365.0
95	0.71	2.04	4.21	12.55	26.09	47.86	77.41	100.8	146.7	203.7	272.9	355.2
100	0.69	1.99	4.10	12.23	25.43	46.65	75.45	98.26	143.0	198.6	266.1	346.3
110	0.66	1.89	3.91	11.69	24.24	44.48	71.93	93.69	136.3	189.3	253.7	330.1
120	0.63	1.81	3.74	11.17	23.21	42.58	68.87	89.70	130.5	181.3	242.9	316.1
130	0.61	1.74	3.59	10.73	22.30	40.91	66.17	86.18	125.4	174.2	233.3	303.7
140	0.58	1.68	3.46	10.34	21.49	39.42	63.76	83.05	120.8	167.8	224.8	292.6
150	0.57	1.62	3.35	9.99	20.76	38.08	61.60	80.23	116.7	162.1	217.2	282.7
160	0.55	1.57	3.24	9.67	20.11	36.88	59.65	77.68	113.0	157.0	210.3	273.7
170	0.53	1.52	3.14	9.39	19.50	35.78	57.87	75.36	109.6	152.3	204.0	265.6
180	0.52	1.48	3.06	9.12	18.96	34.77	56.23	73.24	106.5	148.0	198.3	258.1
190	0.50	1.44	2.97	8.88	18.45	33.84	54.73	71.29	103.6	144.1	193.0	251.2

*To calculate the multiplier for a line of any length divide the multiplier for a 1-mile line by the square root of the length of the line in miles.

EXACT 40 FOOT LENGTHS

REDUCE INSTALLATION COSTS

Here's another thing pipe buyers like about Armco Spiral Welded Pipe. Every section is exactly 40 feet long, or as specified. This results in fewer welded or mechanical joints per mile, besides reducing the cost of installing shorter, uneven lengths.

Tests prove that the spiral butt-welded seam on Armco pipe is fully as strong as the parent metal. Then too, since we supply this pipe with beveled ends, it can be field welded faster and more economically than heavy-end pipe.

Order Armco "Spiral Welded" for that next gathering or transmission line. On-schedule-delivery is assured for all diameters from 6 to 36 inches: wall thicknesses 12 gage to ½-inch. Address: The American Rolling Mill Co., Pipe Sales Division, Middletown, Ohio: 538 Mayo Bldg., Tulsa, Okla., 3500 Maury St., Houston, Tex.

ARMCO

SPIRAL WELDED PIPE

TOTAL[1] UPWARD PRESSURE AT WELL HEAD BETWEEN CASINGS OF VARIOUS SIZES, LB.

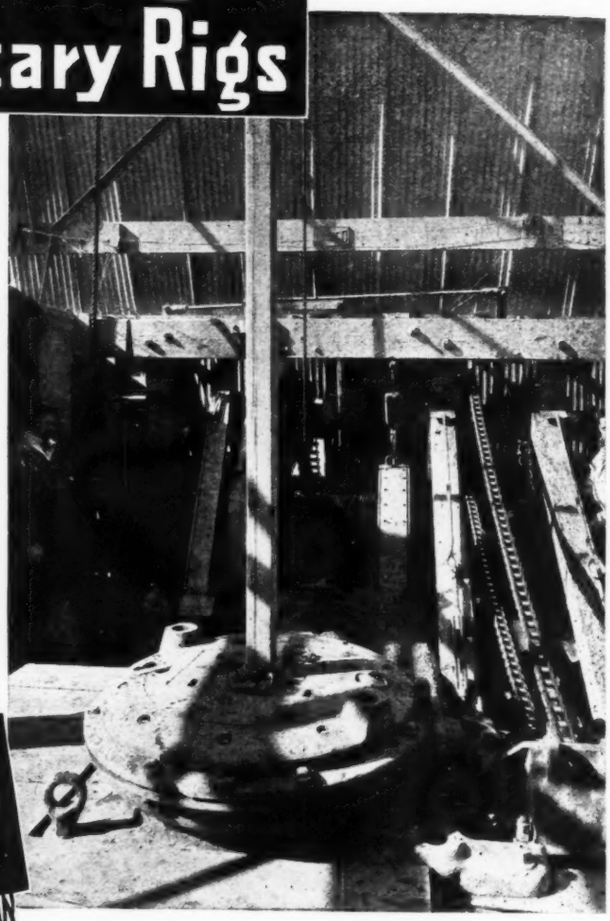
Diam. of larger casing, O.D., in.	Diam. of smaller casing O.D., in.	Well head pressure, lb. per sq. in. gauge																	
		1000	2000	3000	3500	4000	4500	5000	5500	6000	6250	6500	6750	7000	7200	7400	7600	7800	8000
13	6	93,230	186,460	279,690	326,300	372,920	419,540	446,150	512,760	559,380	582,690	606,000	629,300	652,610	671,256	689,900	708,550	727,190	745,840
	6⅝	87,030	174,060	261,100	304,610	348,130	391,640	435,160	478,680	522,190	543,950	565,710	587,470	609,220	626,630	644,040	661,440	678,850	696,260
	7	83,020	166,040	249,060	290,570	332,080	373,590	415,100	456,600	498,110	518,870	539,620	560,380	581,130	597,740	614,340	630,940	647,550	664,150
	7⅝	75,840	151,680	227,520	265,440	303,360	341,280	379,200	417,120	455,040	474,000	492,960	511,920	530,880	546,050	561,220	576,380	591,550	606,720
	8	71,240	142,480	213,710	249,330	284,950	320,570	356,190	391,810	427,430	445,240	463,050	480,860	498,670	512,910	527,160	541,410	555,660	569,900
	8⅛	69,660	139,310	208,960	243,790	278,620	313,450	348,280	383,100	417,930	435,340	452,760	470,170	487,580	501,520	515,450	529,380	543,310	557,240
	8⅝	63,080	126,160	189,230	220,770	252,310	283,850	315,390	346,930	378,470	394,240	410,010	425,780	441,550	454,160	466,780	479,390	492,010	504,620
	9	57,890	115,770	173,660	202,600	231,550	260,490	289,440	318,380	347,320	361,790	376,270	390,740	405,210	416,790	428,360	439,940	451,520	463,100
	9⅝	48,740	97,490	146,230	170,600	194,980	219,350	243,720	268,090	292,460	304,650	316,840	329,020	341,210	350,960	360,710	370,450	380,200	389,950
	10	42,960	85,930	128,890	150,370	171,860	193,340	214,820	236,300	257,780	268,520	279,270	290,010	300,750	309,340	317,930	326,530	335,120	343,710
	10¾	30,740	61,480	92,220	107,5 0	122,960	138,330	153,700	169,080	184,450	192,130	199,820	207,500	215,190	221,340	227,480	233,630	239,780	245,930
13⅜	6	98,700	197,410	296,110	345,460	394,810	444,160	493,520	542,870	592,220	616,890	641,570	666,250	690,920	710,660	730,400	750,140	769,880	789,620
	6⅝	92,500	185,010	277,520	323,770	370,020	416,270	462,520	508,780	555,030	578,160	601,280	624,410	647,540	666,040	684,540	703,040	721,540	740,040
	7	88,490	176,980	265,480	309,720	353,970	398,210	442,460	486,710	530,950	553,080	575,200	597,320	619,440	637,140	654,840	672,540	690,240	707,940
	7⅝	81,310	162,630	243,940	284,600	325,250	365,910	406,560	447,220	487,880	508,210	528,530	548,860	569,190	585,450	601,720	617,980	634,240	650,500
	8	76,710	153,420	230,130	268,490	306,840	345,200	383,560	421,910	460,270	479,440	498,620	517,800	536,980	552,320	567,660	583,000	598,350	613,690
	8⅛	75,130	150,260	225,380	262,950	300,510	338,080	375,640	413,200	450,770	469,550	488,330	507,110	525,900	540,920	555,950	570,970	586,000	601,020
	8⅝	68,550	1 7,100	205,650	239,930	274,200	308,480	342,760	377,030	411,310	428,440	445,580	462,720	479,860	493,570	507,280	520,990	534,700	548,410
	9	63,360	126,720	190,080	221,760	253,440	285,120	316,800	348,480	380,160	396,000	411,840	427,680	443,520	456,190	468,860	481,540	494,210	506,880
	9⅝	54,220	108,430	162,650	189,760	216,870	243,980	271,080	298,190	325,300	338,860	352,410	365,960	379,520	390,360	401,210	412,050	422,890	433,740
	10	48,440	96,870	145,310	169,530	193,750	217,970	242,180	266,400	290,620	302,730	314,840	326,950	339,060	348,750	358,430	368,120	377,810	387,500
	10¾	36,210	72,430	108,640	126,750	144,860	162,960	181,070	199,180	217,280	226,340	235,390	244,440	253,500	260,740	267,980	275,230	282,470	289,710
14	6	111,580	223,150	334,730	390,520	446,300	502,090	557,880	613,670	669,460	697,350	725,240	753,140	781,030	803,350	825,660	847,980	870,290	892,610
	6⅝	105,380	210,760	316,130	368,820	421,510	474,200	526,890	579,580	632,270	658,610	684,960	711,300	737,650	758,720	779,800	800,870	821,950	843,020
	7	101,360	202,730	304,100	354,780	405,460	456,140	506,820	557,510	608,190	633,530	658,870	684,210	709,560	729,830	750,100	770,370	790,650	810,920
	7⅝	94,190	188,370	282,560	329,650	376,740	423,840	470,930	518,020	565,120	588,660	612,210	635,760	659,300	678,140	696,980	715,810	734,650	753,490
	8	89,580	179,170	268,750	313,540	358,340	403,130	447,920	492,710	537,500	559,900	582,300	604,690	627,090	645,000	662,920	680,840	698,760	716,670
	8⅛	88,000	176,000	264,000	308,000	352,000	396,000	440,000	484,010	528,010	550,010	572,010	594,010	616,010	633,610	651,210	668,810	686,410	704,010
	8⅝	81,420	162,850	244,270	284,980	325,700	366,410	407,120	447,830	488,540	508,900	529,260	549,610	569,970	586,250	602,540	618,820	635,110	651,390
	9	76,230	152,470	228,700	266,820	304,930	343,050	381,160	419,280	457,400	476,460	495,510	514,570	533,630	548,880	564,120	579,370	594,620	609,860
	9⅝	67,090	134,180	201,270	234,820	268,360	301,900	335,450	369,000	402,540	419,310	436,080	452,860	469,630	483,050	496,470	509,880	523,300	536,720
	10	61,310	122,620	183,930	214,580	245,240	275,900	306,550	337,200	367,860	383,190	398,520	413,840	429,170	441,430	453,690	465,960	478,220	490,480
	10¾	49,090	98,170	147,260	171,800	196,350	220,890	245,440	269,980	294,520	306,790	319,070	331,340	343,610	353,430	363,240	373,060	382,880	392,700
	11¾	31,420	62,830	94,250	109,960	125,660	141,370	157,080	172,790	188,500	196,350	204,200	212,060	219,910	226,200	232,480	238,760	245,040	251,330
	12	26,750	53,500	80,260	93,630	107,010	120,380	133,760	147,140	160,510	167,200	173,890	180,580	187,260	192,610	197,960	203,320	208,670	214,020

The fact that total well head pressures for unit pressures as high as 8000 lb. per sq. in. are included in the table should not be interpreted as indicating that the casing will have sufficient bursting strength to withstand such pressure. For bursting strength of casing see Table P432.2, p. 257, August, 1937, issue.

[1]Total for lightest weight casing, hence a maximum for each size casing.

Let this NON-ROTATING Wire Line by Gilmore introduce you to a more satisfactory and longer service on your Rotary Rigs

J&L STEEL



— not only that — but it acts equally better in cable tool service.

As you know this has often heretofore been a difficult line to handle but we have licked the difficulty out of it and now you will get performance of an unusually satisfactory nature out of it.

We want to prove to you that Gilmore precision lines are the lines you will be glad to use.

Let us supply you with your next replacement.

GILMORE WIRE ROPE DIVISION

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JONES & LAUGHLIN STEEL CORPORATION

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Other J & L Steel Products:

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FRICK-REID SUPPLY CORPORATION, Distributors

PITTSBURGH—TULSA • BRANCHES IN OLD AND NEW FIELDS

BELT SPEED, FT. PER MINUTE

Diam. of pulley, in.	Revolutions of pulley per minute																														
	500	525	550	575	600	625	650	675	700	725	750	775	800	825	850	875	900	925	950	975	1000	1050	1075	1100	1150	1175	1200	1250	1300	1350	1400
2	262	275	288	301	314	327	340	354	367	380	393	406	419	432	445	458	471	484	497	510	523	550	563	576	602	615	628	654	680	707	733
2½	327	344	360	376	393	409	426	442	458	475	491	507	523	540	556	573	589	605	622	638	654	687	703	720	752	769	785	818	851	883	916
3	392	412	432	452	471	491	510	530	550	569	589	608	628	648	667	687	707	726	746	766	785	825	844	864	903	922	942	982	1021	1060	1100
3½	458	481	504	527	550	573	596	618	642	665	687	710	733	756	779	802	825	847	870	893	916	962	985	1008	1053	1076	1100	1145	1191	1237	1283
4	524	550	576	602	628	655	681	707	733	759	785	812	838	864	890	916	942	969	995	1021	1047	1100	1125	1152	1204	1230	1257	1309	1361	1414	1466
4½	589	618	648	677	707	736	766	795	825	854	883	913	942	972	1001	1031	1060	1089	1119	1148	1178	1237	1266	1296	1355	1384	1413	1472	1531	1590	1649
5	655	687	720	752	785	818	851	884	916	949	982	1014	1047	1080	1113	1145	1178	1211	1244	1276	1309	1374	1407	1440	1505	1537	1571	1636	1702	1767	1833
5½	720	756	792	828	864	900	936	972	1008	1044	1080	1116	1152	1188	1224	1260	1296	1332	1368	1404	1440	1512	1547	1584	1656	1691	1728	1800	1872	1944	2016
6	785	825	864	903	942	982	1021	1060	1100	1139	1178	1217	1257	1296	1335	1374	1414	1453	1493	1532	1571	1649	1688	1728	1806	1845	1885	1964	2042	2121	2199
7	916	962	1008	1054	1100	1145	1191	1237	1283	1329	1374	1420	1466	1512	1558	1604	1649	1695	1741	1787	1833	1924	1969	2016	2107	2152	2199	2291	2382	2474	2566
8	1047	1100	1152	1204	1257	1309	1361	1414	1466	1518	1571	1623	1676	1728	1780	1833	1885	1937	1990	2042	2094	2199	2251	2304	2409	2460	2513	2618	2723	2827	2932
9	1178	1237	1296	1355	1414	1473	1532	1590	1649	1708	1767	1826	1885	1944	2003	2062	2121	2179	2239	2297	2356	2474	2532	2592	2710	2767	2827	2945	3063	3181	3299
10	1309	1374	1440	1505	1571	1636	1702	1767	1833	1898	1964	2029	2094	2160	2225	2291	2356	2422	2488	2553	2618	2749	2813	2880	3011	3075	3142	3273	3403	3534	3665
11	1440	1512	1584	1656	1728	1809	1872	1944	2016	2088	2160	2232	2304	2376	2448	2520	2592	2664	2737	2808	2880	3024	3095	3168	3312	3382	3456	3600	3744	3888	4032
12	1571	1649	1728	1806	1885	1964	2042	2121	2199	2276	2356	2435	2513	2592	2670	2749	2827	2906	2985	3063	3142	3299	3376	3456	3613	3690	3770	3927	4084	4241	4398
13	1702	1787	1872	1957	2042	2127	2212	2297	2382	2467	2553	2638	2723	2808	2893	2978	3063	3148	3234	3318	3403	3573	3657	3744	3914	3997	4084	4254	4424	4595	4765
14	1833	1924	2016	2107	2199	2291	2382	2474	2566	2657	2749	2841	2932	3024	3115	3207	3299	3390	3483	3574	3665	3848	3938	4032	4215	4305	4398	4582	4765	4948	5131
15	1964	2062	2160	2258	2356	2454	2553	2651	2749	2847	2945	3043	3142	3240	3338	3436	3534	3632	3732	3829	3927	4123	4220	4320	4516	4612	4712	4909	5105	5301	5498
16	2094	2199	2304	2409	2513	2618	2723	2827	2932	3037	3142	3246	3351	3456	3560	3665	3770	3875	3981	4084	4189	4398	4501	4608	4817	4920	5027	5236	5445	5655	5864
17	2225	2337	2448	2559	2670	2782	2893	3004	3115	3227	3338	3449	3560	3672	3783	3894	4006	4117	4229	4339	4451	4673	4782	4896	5118	5227	5341	5563	5786	6008	6231
18	2356	2474	2592	2710	2827	2945	3063	3181	3299	3416	3534	3652	3770	3888	4006	4123	4241	4359	4478	4595	4712	4948	5064	5184	5419	5535	5655	5891	6126	6362	6598
19	2487	2611	2736	2860	2985	3109	3233	3358	3482	3606	3731	3855	3979	4104	4228	4352	4477	4601	4727	4850	4974	5223	5345	5472	5720	5842	5969	6218	6466	6715	6964
20	2618	2749	2880	3011	3142	3273	3403	3534	3665	3796	3927	4058	4189	4320	4451	4582	4712	4843	4976	5105	5236	5498	5626	5760	6022	6150	6284	6546	6806	7068	7330
21	2749	2886	3024	3161	3299	3436	3574	3711	3848	3986	4123	4261	4398	4536	4673	4811	4948	5085	5224	5360	5498	5773	5908	6048	6323	6457	6598	6873	7147	7422	
22	2880	3024	3168	3312	3456	3600	3744	3888	4032	4176	4320	4464	4608	4752	4896	5040	5184	5328	5473	5616	5760	6048	6189	6336	6624	6765	6912	7200			
23	3011	3161	3312	3462	3613	3763	3914	4064	4215	4366	4516	4667	4817	4968	5118	5269	5419	5570	5722	5871	6022	6323	6470	6624	6925	7072	7226				
24	3142	3299	3456	3613	3770	3927	4084	4241	4398	4555	4712	4869	5027	5184	5341	5498	5654	5812	5971	6126	6284	6598	6752	6912	7226	7380					
26	3403	3574	3744	3914	4084	4254	4424	4595	4765	4935	5105	5275	5445	5616	5786	5956	5890	6054	6219	6381	6545	6872	7033	7200							
28	3665	3848	4032	4215	4398	4582	4765	4948	5131	5315	5498	5681	5864	6048	6230	6414	6126	6296	6468	6636	6806	7146									
30	3927	4123	4320	4516	4712	4910	5105	5301	5498	5694	5891	6086	6284	6480	6676																
32	4189	4398	4608	4817	5027	5236	5445	5655	5864	6074	6284	6492	6702																		
34	4451	4673	4896	5118	5341	5563	5786	6008	6230	6454																					
36	4712	4948	5184	5419	5655	5891	6126	6362																							
38	4974	5223	5472	5720	5969	6218	6466																								
40	5236	5498	5760	6022	6284	6546																									
42	5498	5773	6048	6322	6598																										
44	5760	6048	6336																												
46	6022	6322																													
48	6284																														

Diam. of pulley, in.	Revolutions of pulley per minute																														
	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500	3550	3600	3800	4000
2	759	785	811	838	864	890	916	942	968	995	1021	1047	1100	1152	1204	1256	1309	1362	1414	1466	1518	1571	1623	1675	1728	1780	1832	1859	1885	1990	2094
2½	949	982	1014	1047	1080	1112	1145	1178	1211	1243	1277	1309	1375	1440	1505	1571	1636	1701	1767	1832	1898	1963	2028	2094	2160	2225	2291	2323	2356	2487	2618
3	1139	1178	1217	1256	1296	1335	1375	1414	1453	1492	1531	1571	1650	1728	1806	1885	1963	2042	2120	2199	2277	2356	2434	2513	2592	2670	2749	2788	2827	2985	3142
3½	1328	1375	1420	1466	1512	1557	1603	1650	1695	1741	1787	1832	1924	2016	2108	2199	2291	2382	2474	2565	2657	2748	2840	2932	3024	3115	3207	3253	3298	3481	3665
4	1518	1571	1622	1676	1728	1780	1833	1885	1937	1990	2042	2094	2199	2304	2409	2513	2618	2723	2827	2932	3037	3142	3246	3351	3456	3560	3665	3718	3770	3979	4189
4½	1708	1767	1825	1885	1944	2003	2061	2120	2180	2238	2297	2356	2474	2592	2710	2827	2945	3063	3181	3298	3416	3534	3651	3769	3888	4005	4123	4182	4241	4477	4712
5	1898	1964	2028	2094	2160	2225	2291	2356	2422	2487	2553	2618	2749	2880	3011	3142	3273	3403	3534	3665	3796	3926	4057	4188	4320	4451	4582	4647	4712	4974	5236
5½	2088	2160	2231	2304	2376	2448	2520	2592	2664	2736	2808	2880	3024	3168	3311	3456	3599	3743	3887	4031	4175	4319	4462	4607	4752	4895	5040	5111	5183	5472	5760
6	2278	2356	2434	2513	2592	2670	2749	2827	2906	2985	3063	3142	3299	3456	3613	3770	3927	4084	4241	4398	4555	4712	4869	5026	5184	5341	5498	5576	5655	5969	6283
7	2657	2749	2840	2932	3024	3115	3207	3299	3390	3482	3574	3665	3848	4032	4215	4398	4582	4765	4948	5131	5315	5497	5681	5864	6048	6230	6414	6506	6596	6963	7330
8	3037	3142	3245	3351	3456	3560	3665	3770	3875	3979	4084	4189	4398	4608	4817	5027	5236	5445	5655	5864	6074	6284	6492	6702	6912	7120	7330	7436	7540		
9	3416	3534	3651	3770	3888	4006	4123	4241	4359	4477	4595	4712	4948	5184	5419	5655	5891	6126	6361	6596	6832	7068	7302								
10	3796	3927	4057	4189	4320	4451	4582	4712	4843	4974	5105	5236	5498	5760	6022	6284	6546	6806	7068	7330											
11	4176	4320	4463	4608	4752	4896	5040	5184	5328	5472	5616	5760	6048	6336	6623	6912	7199														
12	4555	4712	4868	5027	5184	5341	5498	5655	5812	5969	6126	6284	6598	6912	7226																
13	4935	5103	5274	5445	5616	5786	5956	6126	6296	6466	6637	6807	7147																		
14	5315	5498	5680	5864	6048	6230	6414	6598	6780	6964	7148	7330																			
15	5694	5891	6085	6283	6480	6675	6872	7069	7265	7461																					
16	6074	6284	6490	6702	6912	7120	7330	7540																							
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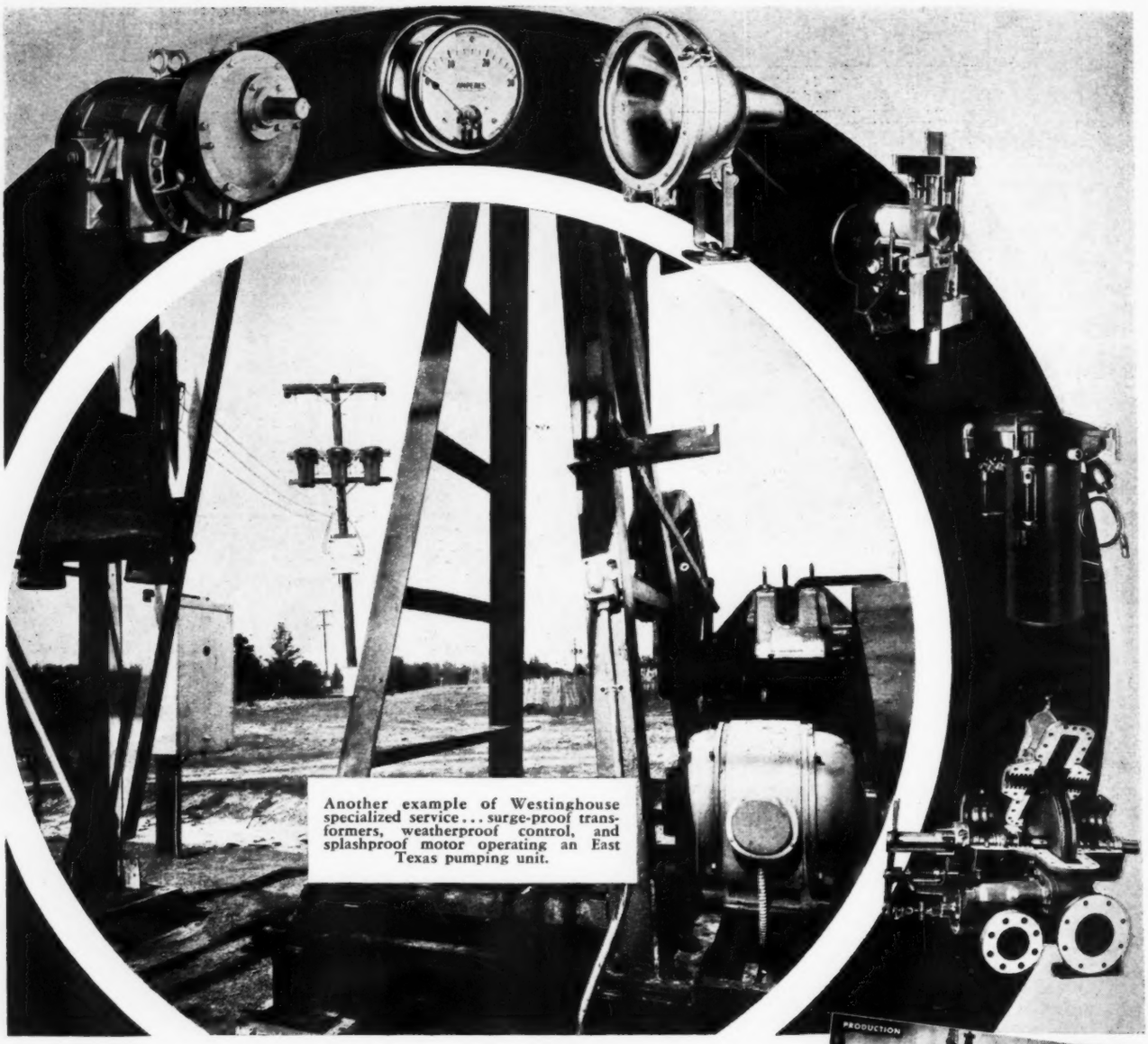
18	6832	7068	7302																												
19	7212	7461																													



Another example of Westinghouse specialized service... surge-proof transformers, weatherproof control, and splashproof motor operating an East Texas pumping unit.

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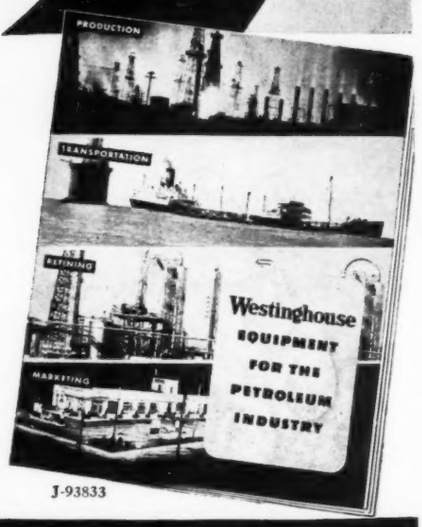

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